THE PERCEPTION OF GEOGRAPHICAL DISTANCE AND THE PHILOSOPHY OF SPACE

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ABSTRACT

The thesis is divided into five parts.

I) In the introduction, the existing theory of cognitive distance is discussed and amplified, with emphasis on the differences between a psychological and a geographical approach to the subject.

II) A brief thematic history of the philosophy of space is given, from the behavioural geographer's point of view. The ways in which the nature of space could affect the perception of distance are discussed.

III) An account of a large experiment investigating the perception of global distances is set out. Students from three universities estimated distances to 24 places ranging in distance from Dublin to Christchurch, N.Z. In the analysis of the results a completely new methodology is introduced to deal with misestimation. Consideration is given to globe and map distances, degree of certainty on the part of the subject, cognitive barriers, logarithmicity of estimation and descriptive statistics.

IV) The second major experiment involved asking citizens in ten Scottish and North British towns to estimate distances to all the other towns in the experiment. Investigation is made of the commutativity of cognitive space, road and direct distances, logarithmicity, familiarity of destination, attractiveness of destination, the effects of travel time, certainty on the part of the subject, four different cognitive barriers and the comparability of the different subject groups.

V) A brief recapitulation of the results, linking some of the themes from the preceding four parts, forms the conclusion of the work.

Author's Note

While every effort has been made to keep the text of this thesis up to date, obviously there is a limit to the amount of last-minute alterations that can be made. The bibliography should be considered as dating from June 1978, and material published after that date will not be found.

Declaration:

I, Roger Musson, declare this thesis to have been composed by myself; also that the work herein is entirely original.

PART I

INTRODUCTION

At the Dublin wedding of President O'Kelly's daughter, not so very long ago, one of the guests, a Belfast member of the Irish Association, was complimented by the President on having come so far to attend. The Ulsterman respectfully pointed out that Belfast was no further from Dublin than Cork was, and surely travelling from Cork to Dublin was no feat worthy of mention.

Clearly something other than spatial separation was influencing the President in the formation of his judgement of relative distance. Some factor, the Irish border, perhaps, was making the distance to Belfast appear longer than it really was, and the subsequent behaviour of the President (making the particular compliment to the Belfastman) was therefore based on a conception of distance which, objectively speaking, was erroneous. Nor is this exceptional; misunderstanding about distance is rife. When Donald Klein wrote to Newsweek in 1971 picking them up for misrepresenting distance in a headline that described Chile as on the "U.S. doorstep" (Moscow, he pointed out, was closer to New York than Santiago was), he can hardly have expected that his letter would be reproduced in academic books on both sides of the Atlantic in the next six years. But it serves as an excellent example of how expected distance relations, based on non-spatial information (for example, the similarity of place names: North America and South America) often turn out to be false when compared to an accurate geographical treatment of distances.

The problem is a complicated one, with many twists and turns. Klein is in turn criticised by Canter (1977) for representing New York as being the whole of the U.S.A. - as Canter rightly points out, if the relative distance to Moscow and Santiago is compared from other points in the United States, different relations occur. (But then again, Moscow is not all of Russia, nor is Santiago all of Chile.) What makes matters worse is that these relationships also change according to how one defines one's "real" standard - if one turns to an atlas map for such information as distances between the United States and Chile, one can be dangerously misled, for atlas map distances and great circle distances are very different things. On a map, Vancouver may appear tó be twice as far from London as New York is; when one takes into account trans-polar flight the relationship is considerably altered.

Somewhere, there is a message for geography. If human spatial behaviour is based on objectively incorrect conceptions of relative distance, then theories that posit particular patterns of human behaviour based on correct knowledge of distance will tend to break down. But if it is possible to build a predictive model of the ways in which people distort distance, then the position can, one hopes, be salvaged. However, research into this topic of distorted distance conceptions is still in its early stages; there is some pratical work extant, but very little theorisation.

Before we proceed further, it is necessary to deal with some technical terms. There is a tendency to deal with that part of behavioural geography which concerns itself with man's conceptions and misconceptions of his environment under the heading of "perceptual geography". We talk about man's perception of the environment, his perception of natural hazards; we might very well talk about his perception of geographical distance.

Technically speaking, this would be wrong. Convention has laid down strict parameters for the use of the word "perception", and the phrase "perception of distance" is taken to refer exclusively to distance perceived directly and in toto by the visual process. One may perceive the distance across a field, but not down a winding street, or on a map. Nor may one talk about the perception of distance with regard to the drawing upon of stored memories of distances once directly observed. Instead the word "cognition" is used. The various processes by which one might build up an idea as to how far it is from Edinburgh to Aberdeen are cognitive processes, inasmuch as they are a mixture of direct experience (but over a course of time, and not instantaneous) and remembered information of various sorts, from maps, conversations, road signs, books and so on. The distances on which we base our spatial behaviour are cognitive distances; it is the cognitive distance from New York to Chile that Klein found shorter than physical distance, while President O'Kelly cognised Belfast as being, relatively speaking, further away than it really was.

However, there is a danger here of splitting hairs. Is an aerial view of the distance between two points a perception or a cognition? If the former, the same must go for the observation of distance on an accurate map. Furthermore, "perception" is a more familiar word, and more useful when addressing the uninitiated; it is not helpful to have its use so strictly curtailed. As evidenced by the title to this work, the author has no intention of strictly adhering to this convention. At the geographical level, there are few distances that qualify as "geographical distances" that can be perceived instantaneously and in the approved manner rather than cognised; in the work that follows, there are none. Therefore, with the reader's indulgence, we shall regard the phrases "the perception of geographical distance" and "the cognition of geographical distance" as interchangeable in the text that follows, on the understanding that we shall never be dealing with distances to a destination that can be directly observed from the origin.

The further term "subjective distance" might appear, on the face of it, to be also synonymous with distance perceived or cognised, and indeed, some researchers may have assumed this to be so. However, the phrase has a specialised usage in meaning "distance as it is imagined to be, irrespective of what the respondent in question knows it actually to be". In other words, a respondent asked to estimate subjective distance to two places must, if he knows the actual distances to these places, forget this and imagine what answer he would give if he didn't know. If this sounds to the reader like an artificial construction, be assured that the author agrees entirely. (However, it is perhaps unfair to introduce the term in such a way. In part III, section (v), a background is provided to illustrate the origin of the term in its specialised usage.) Cognitive distance, unlike subjective distance, is what the individual really thinks the distance is, right or wrong, and it is on this that he bases decisions.

Ultimately, if we are going to understand cognitive distance, we will need to propose some sort of theoretical model to represent the mechanisms by which the cognitive processes operate. The greater contribution to the development of theory in this respect has come from two researchers, Briggs (1973a) and Canter (1975); but here a curiosity arises: going by university departments, Briggs is a geographer, while Canter is a psychologist. What is the effect of this interdisciplinary split? Before discussing their theoretical propositions in depth, it is necessary to establish the position of cognitive distance vis a vis the two disciplines of geography and psychology.

It has already been mentioned that cognitive distance is of concern to geographers. What has not been shown is that cognitive distance studies lie within the competence of geographers. Three elements can be discerned in any perceptual problem: the objective world, the geographical or phenomenal environment (to use Kirk's (1951) phrase) which acts as initial material; the "world in the head", the cognitive or behavioural environment which is the "end product"; and, in between, the complicated processes that turn the one into the other. These last are the perceptual mechanisms, cultural conditioning, and so on, that we can call (rather loosely) "mind". Cognitive distance itself takes its place as part of the behavioural environment. The real distance that it mirrors is clearly part of the geographer's world, but the mental mechanisms that lie in between, the perceptual processes, are equally clearly the psychologist's domain.

If there is going to be any fruitful investigation of cognitive distance at all, it is going to be necessary that cognitive distance should display regularities; if, as a phenomenon, it is totally chaotic, nothing significant can be said about it by any discipline. If on the other hand, it is found that order and regularity can be established by the investigation of cognitive distances, the important question is this: does this order mirror regularities in the geographical environment, or variations that are purely psychological? Or are both sorts of dependencies observable? Clearly, if it can be shown that patterns detectable in the cognition of distance are purely conditioned by the people involved; that theories are likely to take the form "distances will be overestimated by people who are x" where x is some physiological/psychological characteristic, then there is little the geographer can contribute. It is necessary that one should be able to formulate theories along the lines of "distances will be overestimated to places that are y", where y is an appropriate geographical variable. Unless this can be established, there is little point in attempting a geography of cognitive space.

Assuming that this can be established, various correlative positions can be reached. If it is found that the phenomenal environment contributes sufficently to cognitive distance for a geographical approach to the topic to be undertaken, it may still be true that psychological variables play a sufficently significant part to make a psychological perspective equally valid. Or it is possible, though, we suspect, unlikely, that if the mechanisms of perception process distance without passing on to it any pattern of their own, a psychological approach to the topic is not appropriate after all. The third possibility is that a sociological approach may also be valid - were it discovered that significant theories could be formulated along the lines of "distances will be overestimated by people who are z" where z is a sociological variable, such as membership of a particular income group. However, as yet, sociologists do not appear to be all that interested in this potential.

The psychological and sociological aspects of cognition are not intended as the subject matter of this thesis. The fundamental aims of this thesis are threefold: firstly, to investigate the validity of a geographical approach to cognitive distance (as outlined above), in which variation in the perception of geographical distance is shown to relate in some significant manner to spatial or place characteristics. Secondly, it is intended to examine some of the potential components of a geographical theory of cognitive distance. Thirdly, since distance is a spatial variable, and the existence of cognitive distance invokes a correlative cognitive space, it is intended to make comparisons between cognitive space and the theories of physical space put forward by various philosophers. Our hypothesis in this is that the nature of physical space itself may encourage the mind in translating physical space into cognitive space in a particular manner. Just as the structure of a language may encourage thinking that uses the ideas of that language in a particular pattern related to the language's structure, so the structure of physical space may similarly affect the way we deal with such spatial phenomena as distance and the estimation of distance.

That said, we can now return to the theories of Briggs and Canter for the mechanisms of distance cognition, and add a contribution of our own.

Briggs (1973a) postulates five possible mechanisms by which distance can be cognised, as follows:

(i) Motory response - judging distance by the amount of effort expended in overcoming it, i.e. by walking. Distances uphill should presumably appear longer than ones downhill by this hypothesis.

(ii) Time and velocity - if one knows the speed at which one travels, plus the time taken to traverse a particular distance, one can calculate the approximate distance covered.

(iii) Perception - if the whole distance cannot be simultaneously perceived, it can be divided up into segments or links which can be perceived separately, and these perceptions can then be fused into one composite image.

(iv) Patterns within the structure of the external environment - if a distance includes a regular patterning, for example, telegraph poles every so many hundred yards apart, by counting the number of regular elements passed, one may estimate distance travelled.

(v) Symbolic representations - maps, roadsigns, etc.

Briggs himself suggests that "although all five of these mechanisms may operate... the third... is the most general and critical." (Briggs, 1973a, p 188) To Downs and Stea "the answer probably lies in a combination of all of them." (Downs & Stea, 1977, p 140) Certainly all of them bear closer examination, perhaps with the exception of (iv), which can be viewed as a specialised occurence of (iii). The first important point to note is that the fifth mechanism, cognition derived from symbolic representation, is very different from the other four. It is an indirect mechanism, whereas the others are all direct, experiental measures of distance. It is possible to estimate distances to places one has never visited, but only by recourse to the fifth method. Furthermore, if a distance has been personally traversed, but information from a roadsign is also available, the roadsign distance will almost certainly override any of the other possible mechanisms for arriving at an estimate of the distance travelled.

Secondly, note that the fifth mechanism is not homogenous. Road signs and guide books give information about distance in miles or kilometres, and this needs no secondary processing; it is pure information. On the other hand, maps, when recalled rather than directly viewed, can act as a substitute for experiencing the distance, and still be subject to the effects of (iii) and (iv). A combined mechanism can operate whereby a distance is envisaged on a map, or series of maps, in which the entire distance can still not be perceived as a whole, but is thought of in terms of internal segments.

Thirdly, all five mechanisms are to some degree specialised and only applicable in certain conditions. Motory response is only valid for distances actually traversed on foot. Time and velocity can only be used where information on velocity, and, to some extent, time, is available. Regular patterns in the environment are relatively uncommon. Perception requires the distance to be actually perceived (it is not sufficent to have merely read the mileage without experiencing the journey), while symbolic representation is subject to availability. Nevertheless, (iii) and (v) are evidently the most widely applicable, and, as Briggs comments, probably segmental perception is the most general, even though symbolic representation may supercede it where available.

However, there is another point to be made. We have considered here how distance is cognised, but have not asked the question what is it cognised as? A distance exists as so much space, but it must be expressed as something else if it is to be expressed at all. The two most important means of expression to be considered in this context are as absolute distances (in miles or some other measure) or as relative distances (compared to some other distance). To some extent these are similar. One can derive mileage estimates by comparing the set distance to another distance which one knows (or thinks - perhaps incorrectly) to be one mile. But the mechanism one uses for deriving cognitive distance may be deliberately selected according to the required expression. I might use motory response to make a decision as to whether I buy groceries at shop A or B on the basis that as I always feel more tired on returning from shop A, it must logically be that shop A is further to walk to than shop B. On the other hand, were I specifically asked how far it was to shop A in miles, in replying I might use the fact that I have a steady pace (the speed of which I know from measurement) and that I know the average time it takes me to walk the distance in question, and make a time/velocity calculation to arrive at an answer. Similarly, perception of a distance tends to be a relative measurement, whereas symbolic representation tends to be in absolute terms. Further mixing of methods is possible. If I am required to estimate the mileage to place X, I might reason that, on grounds of perception, it would appear to be twice as far to X as it is to another place Z. Then, since I know the distance to Z from symbolic representation, I have simply to double this figure in making my reply. With such a range of alternative methods available, one cannot predict in any simple form the precise mechanism that will be used in any instance of distance estimation and cognition.

Canter (1975) is more concerned with providing an overview of the cognitive process. Figure 1.1 shows the model he suggests. The two initial elements are described as "geographical factors" and "psychological factors." The former include the actual physical distance, also the topography across which the distance runs; the latter are envisaged as including preferences and knowledge as well as cognitive abilities. As for the third group:

"We call these mediational factors because they appear to be made up of variables representing interactions between psychological and geographical variables. They are the variables by which the geography of a city comes to have an impact upon the conceptual system of an individual... The most obvious example of a mediational variable which was identified was that of transport mode, but residential location, type of work, or training, may also be considered in this way." (Canter, 1975,p8)

The box labelled "process of estimation" is presumably Briggs' five mechanisms, or something similar.

In seeking to expand on this model, one aim was to illustrate more clearly the process of estimation, and here an important distinction must be made between perception (or cognition) and estimation. We have a classic "black box" problem; perceptions "go in" and estimations "come out", but there is no way of opening up the box to see what happens in between. It is quite possible that cognitions of distance are distorted in the estimation process, for purely psychological reasons. It is useful, therefore, to distinguish between the stages at which distortion can occur. The position is analagous to the examination of a text which one knows

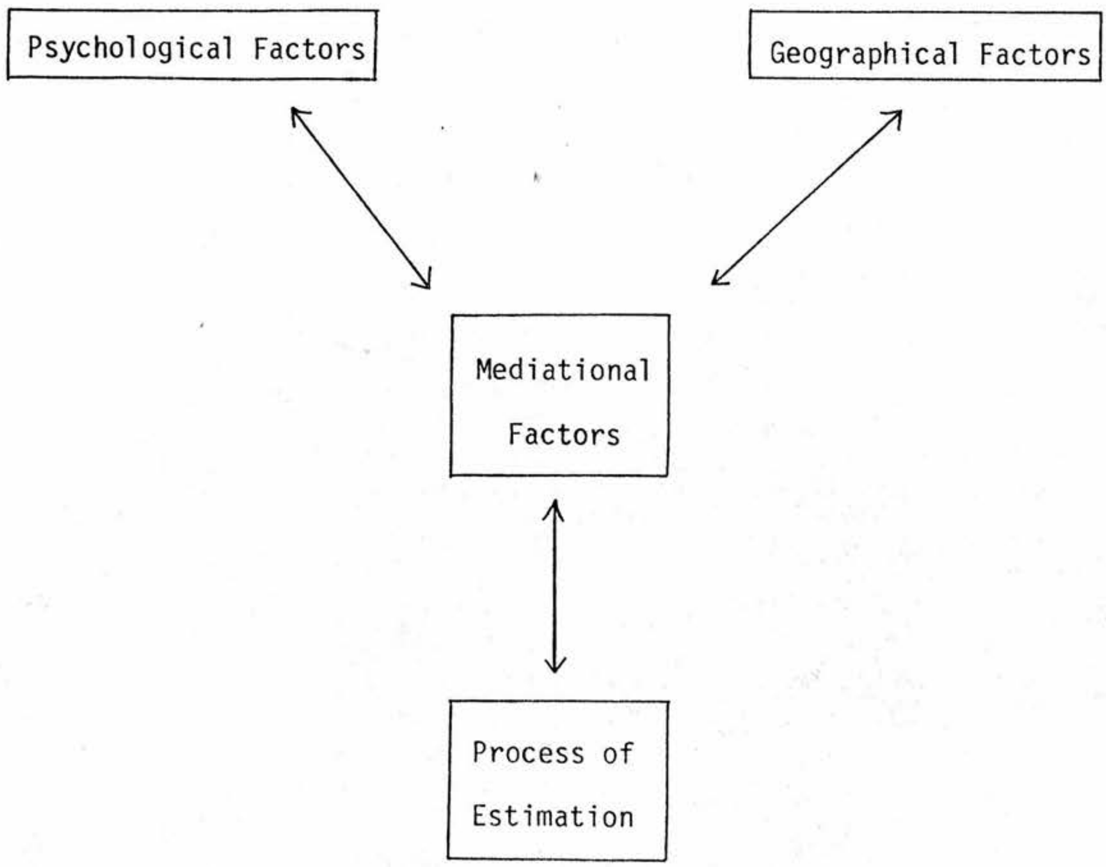


Figure 1.1 (From Canter,1975,p.8)

Model of Distance Cognition

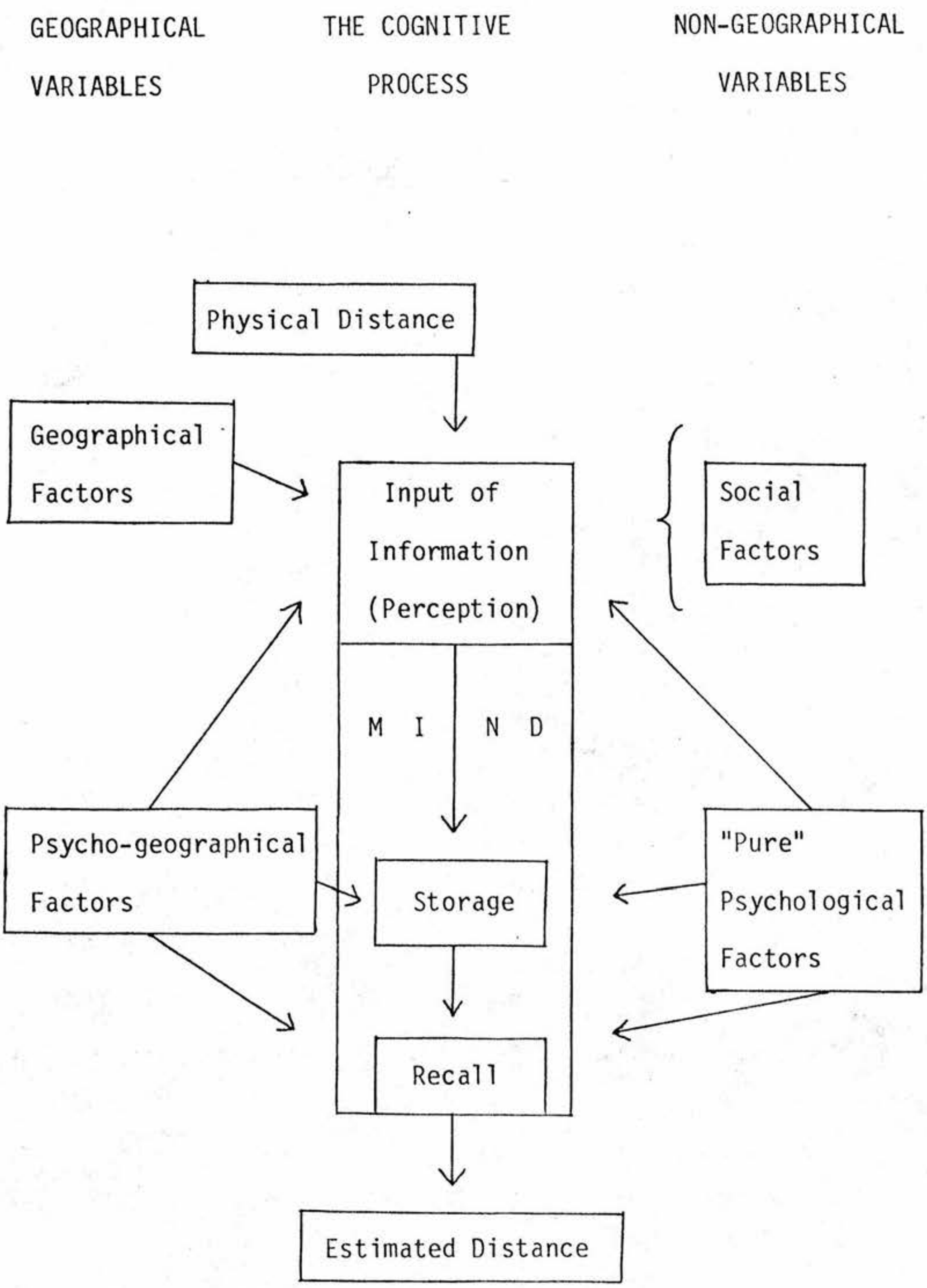


Figure 1.2

Revised Model of Distance Cognition

was translated into English from a Greek translation of a Hebrew original; deficiencies in the text may have crept in as a result of the first translation, or the second translation, or both, and one cannot determine which translator was at fault without a copy of the Greek document. In the cognitive/estimation process the middle document is the cognition stored in some form or other by the brain, and it cannot be accessed to see if the greater error stems from the first translation (perception) or the second (estimation).

Figure 1.2 provides a revised model of the distance estimation process, which, it is hoped, is clearer than figure 1.1. The vertical section labelled "the cognitive process" shows the three main stages: the perception of distance - an input of information either of a direct (experiential) nature or indirect (symbolic) nature. This is then transmitted to some form of storage in the memory. To make a distance estimation, it is necessary to access this stored information by a process of recall, which includes the estimation process itself, and the estimated distance is the final product of the system. The physical distance itself is the starting point of the system as a whole, but it also deserves a mention in the column which we have headed as "geographical variables". This column represents those factors influencing the system which are related to places rather than to persons. These comprise geographical factors of an objective character, such as topography and nature of route, and what we have termed psycho-geographical factors, the subjective characteristics of the places involved. Examples of these are the degree to which the distance is familiar to the respondent, the attractiveness of the destination, and so on; all these are to some extent psychological, but they are place-related. It will be noted that the influence of geographical and psycho-geographical factors is depicted as being different. This is because it seems likely that geographical factors may act most as a purely spatial analogue for distance, as for instance, when the degree of physical segmentation of a route results in information being recorded along the lines of "distance AB is x number of links in length". However, when we look at the effect that more subjective attributes are likely to have, it seems probable that they are active at other stages of the process. For instance, we might hypothesise that when a subject recollects the distance to place X, he may remember at the same time that place X is somewhat unpleasant, and this will subconsciously influence his recall of the distance, perhaps persuading him to overestimate. However, psycho-geographical factors may be active at other stages of the process as well (we really don't know), so they are shown in the diagram as directed to all three stages. The same is true of what we have labelled as "pure" psycholological factors. These are taken to be personal characteristics totally unrelated to place, but including physiological characteristics. Mental aberrations, character type, sex, degree of astigmatism and so on, all come under this category. How they affect distance cognition is uncertain, and, in terms of this thesis, not relevant.

The box labelled "social factors" represents approximately the same thing as Canter's "mediational factors"; such variables as occupation and length of residence. These are seen, in terms of the model, not as directly influencing the cognitive process, but rather as forming a background against which the cognitive process operates. Social factors are likely to decide such questions as to which distances will actually be perceived, how often, and in what circumstances. They are considered as more indirect variables than the others, and again, since they are not directly related to place, they are not considered as falling within the bounds of this study. (Although a word might be said here about travel mode, which is in some ways a special case, in that there is a very loosely discernable link with place, since certain journeys are restricted in terms of available transport mode. One cannot sail to Stirling, nor go by train to Stornoway. However, no place is accessible by one unique transport mode only, and so transport mode per se cannot really be considered an attribute of the place in question. We therefore feel justified in classing it with the non-geographical variables.)

In terms of this model, we are now justified in asking which of the two sets of variables, the geographical or the non-geographical, have the most important influence over the process as a whole? Or, to re-frame the question, does the impact of geographical variables have any influence over the process as a whole? If it does, then we can justify further investigation of the subject using a geographical methodology. This will not in itself, of course, invalidate a purely psychological or psycho-sociological methodology, but we must obviously leave the investigation of non-geographical variables to the non-geographer.

The key difference between the two approaches in terms of examination of results is that the geographer will essentially be looking for variation in results with variation in place, whereas the non-geographer will be primarily concerned with variation in results with variation in person. If results of a cognitive distance study show that it is possible to identify a significant result associated with a particular place, then that is a geographical result; if the identification is of an image held in common by a certain class of person, that, on the other hand, is a psychological or sociological result. There is, of course, no reason why both should not occur. But it has not been shown that they do.

Incidentally, it may be felt that the author is taking an unaccustomedly place-oriented view of what constitutes "geography".

It should be emphasised that this is a pragmatic decision; the implied definition of the borders between the geographical and the non-geographical is a helpful one in delimiting the parameters of this cognitive problem, and no wider implications are intended. What the author has described as sociological factors do, of course, have a geographical component themselves. Should other geographers feel it within their scope to investigate the influence of such factors on cognitive distance, there is no reason why they should not do so.

To recapitulate: the problem that will be examined in this thesis is that of the perception of geographical distance, and the extent to which it is influenced, controlled or distorted by the physical and non-physical attributes of place, and by the physical attributes of distance. However, to touch on the attributes of distance is to enter upon an interesting and complicated philosophical problem in itself. For distance is synonymous to a large degree with the term extension; and extension is the basic parameter of space. What space is, distance is, but what is space? We now turn to a brief examination of the philosophy of space, to see what attributes it may have that could affect the transmission of physical distance into the cognitive system.

PART II

THE PHILOSOPHY OF SPACE

1) THE GEOMETRY OF SPACE

(i) Introduction

"Space is a necessary a priori representation, which underlies all outer intuitions. We can never represent to ourselves the absence of space, though we quite well think it as empty of objects. It must therefore be regarded as the condition of the possibility of appearances, and not as a determination dependent on them. It is an a priori representation which necessarily underlies outer appearances." (Kant, 1929, p.68)

Thus did Immanuel Kant seek to demonstrate the Newtonian concept of absolute space; what the passage better demonstrates is not the absolute nature of space but more the absolute importance of space as a fundamental concept in any natural philosophy. Space is so pervasive a phenomenon, that attempting to define geography as the study of spatial distributions, though it establishes a general frame, is deficent unless particular sets are also distinguished. It is scarcely possible to study anything that is not, in at least a loose sense of the term, a spatial distribution, whether it be a distribution of cities, bones, or atoms themselves. However, the extent to which space itself is a ground for active discussion varies from discipline to discipline. Philosophy, being (at least up to the last fifty years) an enquiry into the ultimate nature of the fundamental phenomena of the universe, has been much concerned with the discussion of so basic a matter. Mathematics, being to a large extent a theoretical subject, has the free range of an infinite number of possible spaces, each of which is theoretically valid and in which consistent geometries may be constructed. Physics is more practically oriented and physicists have concerned themselves from time to time with the possibility of experimentally determining which mathematically possible spaces are of principal utility in the contemplation of natural phenomena, just as the philosopher attempts the same thing from a logical rather than an experimental viewpoint. On the other hand, the anatomist, though concerned with spatial arrangements, is able to take the nature of space as an unvarying constant throughout all his studies. Since it is unvarying, it can be ignored.

Geography, being essentially a varied discipline, is in a more complex situation. Branches of the discipline, especially on the physical side, are in much the same position as anatomy and other subjects that can disregard considerations of the nature of space on the grounds that this is a constant having no active effect on data.

However, other parts of the discipline are more specifically spatially oriented. Often the geographer is concerned not only with objects themselves, but with the abstract spatial relationships between them, "abstract" in the sense that they are being considered in purely mathematical terms, rather than merely as an implication of the data. Using anatomy as an illustration again, the distance between the tarsus and the cranium is important in a concrete sense, in that if it were of insubstantial magnitude, a queer physique would undoubtedly result. But the nature of the distance itself, in the philosophical sense, is not important; as long as there is a distance of appropriate magnitude, that suffices. In geography, on the other hand, there may be different measures of distance possible and the variance between these may be crucial. Between two points A and B we may find the walking distance to be 10 km, the railway distance 12 km, and the road distance 15 km; now in Euclidean geometry, the shortest distance between two points is a straight line, and if our walking distance is a straight line, then we can discuss the relationships of A and B in terms of Euclidean geometry. However, if we are restricted to road distance, and the shortest road distance, 15 km, is not a straight line, then we must think about describing the relationships of A and B in terms of some other geometry. The geographer has become involved in the nature of the distance itself, and therefore the nature of space, of which distance is but a function, has become relevant to geography. And in geography, as Harvey points out, an appropriate metric must be taken for each study in which distance is a variable, to be chosen with regard to the process being studied. (Harvey, 1969)

(ii) Metric Spaces

The debate on space engaged in by various philosphers in the past was largely a debate concerned with the idea of extension - the extension of matter which takes up space and the extension of whatever separates bodies, which also defines space. The measurement of extension, be it length, breadth or height, is primarily a measure of distance and hence it becomes sensible to think of space in terms of the distance function by which it is measured. The concept of metric space is an attempt to make this explicit in terms of a mathematical definition of a space by the nature of the structuring of distance within that space. This can be formalised in an equation, but is a reflection of the mathematical processes involved in measuring distance. This is not measuring in the usual sense, of comparing lengths to arbitrary units marked on rigid rods, but a loose usage of the term to include the calculation of distances by such purely mathematical means as the Pythagorean square-of-the-hypotenuese method. The precise defintion of a metric space in general is a set E for which for any pair of members (M,N) a real number d(M,N) is generated where d is the distance function. There must be only one value for d(M,N) and various other conditions (the network properties) must be met:

symmetry	$d(M,N) = d(N,M)$
non-negativity	$d(M,N) \geqslant 0$
nondegeneracy	$d(M,N) = 0$ only when $M \equiv N$
the triangle inequality	$d(M,L) + d(L,N) > d(M,N)$

where L is any point not on the line MN.

Now, in fact it is perfectly acceptable to regard Euclidean space as a subset of metric space rather than as a different sort of space. To be precise, Euclidean space is a metric space defined as having a distance function such that, with points $M(x,y)$ and $N(x_1,y_1)$,

$$d(M,N) = (|x-x_1|^2 + |y-y_1|^2)^{1/2}.$$

But use of different metrics results in different spaces being defined; the formula

$$d(M,N) = |x-x_1| + |y-y_1|$$

provides us with the so-called "Manhattan Space" where movement is restricted to routes parallel to rectangular axes (see fig. 2.1). This evidently has a geographical counterpart, as its name suggests, in the geometry of grid plan cities where movement is constrained in this way.

When dealing with metric spaces in a geographical context it is possible to incorporate irregularities occuring in the geographical environment into the formulation of an irregular metric space. This concept, though not so mathematically neat as the orthodox metric space, retains most of the network properties and is just as relevant geographically. For example, given the grid plan city used to illustrate "Manhattan Space", and assuming that the grid is not perfectly regular - a ring road might be added, for instance - it will be seen that though the experiential effects of this "space" are essentially similar to those of the regular grid, it is no longer

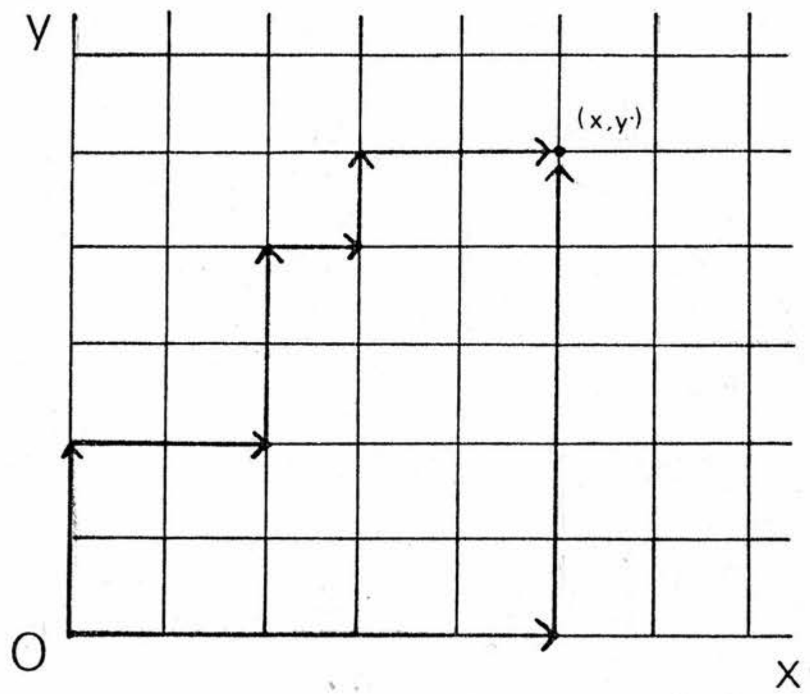


Figure 2.1

Manhattan Space - showing two possible routes from 0 to (x,y) possible to calculate the distance between any two points by means of a simple function similar to the ones given above. It becomes necessary to think of d not as a mathematical constant that can be expressed by an equation, but rather as an instruction to consult a predetermined table of route distances (back, alas, to rigid rods) for the relevant value. This means that we are no longer specifically defining distance as such, since we are virtually saying that

$$d(M,N) = d(M,N)$$

in a roundabout way. But though we may not be defining the distances geometrically, we are still defining space in terms of these distances; the irregular "metric" space could be defined as the set E for which for any pair of members (M,N) a real number d(M,N) is given by the value (M,N) in a matrix of all possible values for interdistances between members of the set. Although this space could be represented using a Euclidean geometry, and though the distance values for the matrix have been measured in a fashion no different from measurement in a conventional Euclidean sense, it is to be emphasised that this is not to say that the irregular metric space is merely a Euclidean space manqué; geometrically it may operate quite differently. For example, the ordinal ranking of a given number of points might be quite different in terms of proximity from one particular point depending on whether one used a metric or a Euclidean geometry (see fig. 2.2).

In fact an irregular metric space constructed to fit a geographical environment may be sufficiently irregular to conspicuously lack some of the defining properties of metric spaces previously listed. In terms of the urban example, the introduction into the geographical environment of a one-way street system does not affect the viability of the representation of the network as a metric

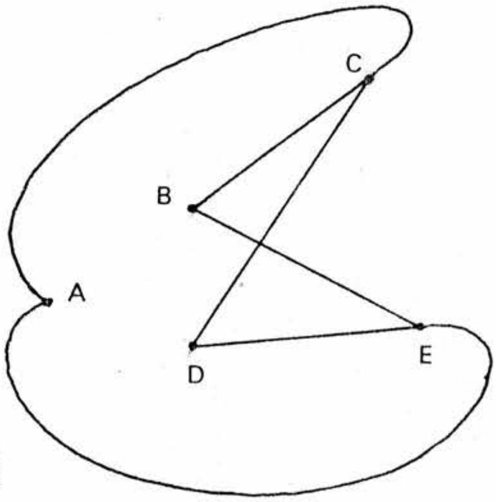


Figure 2.2

Irregular metric space where movement is confined to network links. Note that in the metric space the order of points in terms of proximity to A is C,E,B,D, whereas if a Euclidean geometry were used the order would be D,B,E,C.

space in the manner outlined above, but it does mean that the property of symmetry will not longer be maintained. The matrix of distance values for M_n, N_n will not be symmetrical and the value for d(M,N) may well be different from the value for d(N,M).

The point of looking at space in this way for our present purposes is this: we cannot assume that perceptual space in the geographical sense will turn out to have a Euclidean geometry. If we are concerned with the geometry that perceptual space does exhibit, we must consider some of the possibilities. As can be seen, the use of metric geometries provides a number of ways of diverging from Euclidean principles; the concept of an irregular metric space enlarges the scope still further. We can therefore consider the concept of metric spaces as a useful tool that we may be able to draw upon when wishing to describe the geometry of cognitive distance.

If we wish to represent perceptual space as a metric space, either regular or irregular, we must consider to what extent does it hold to the network properties just discussed? The principle of non-negativity we can expect to automatically apply to cognitive distance for obvious reasons. The question of symmetry is less certain. To a single observer at A, we might expect the distance AB to be considered identical to BA, if only because we expect the observer to be familiar with the "rules" of orthodox geometry. But supposing we use different groups of observers at A, asking one to estimate the distance from A to B, and the other to estimate the distance from B to A, will the result be the same? Or supposing we locate one group of observers at B? The commutativity of cognitive distance is something we cannot take for granted, and therefore we must regard the symmetry of perceptual space as an open issue. Nor can we take the triangle inequality as automatically holding.

With regard to the metric itself, one can easily think of the illustration of intercity distances being cognised exclusively in terms of the road distance - thus framing cognitive distance as an adjunct of the road network. If we discovered road distances to be the foundation of all ideas about intercity distance, we could posit a network cognitive space. Straight line distances appearing in the estimates, on the other hand, would suggest a Euclidean approach.

(iii) Curved Spaces

The use of metric spaces is one way of diverging from the traditional Euclidean framework; different geometries may also be constructed by reference to the notion of curved space. This concept was evolved in the debate on the famous fifth axiom of Euclid, that if a straight line meets two other straight lines so as to make the two interior angles on one side of it together less than two right angles, the other straight lines, if extended indefinitely, will meet on that side on which the angles are less than two right angles (see fig. 2.3). This axiom was known to be thoroughly consistent in all its applications, but it did not seem to be provable in terms of the other four axioms. So in the last century, a reductio ad absurdum proof was attempted by two mathematicians, the Hungarian Bolyai, and the Russian Lobatchevsky, both working independently of one another. The basis of the proof was the implication of the axiom that only one line could be drawn through a given point parallel to a given line not passing through that point. What happened if one made the illicit assumption that more than one parallel could be drawn through any given point? The mathematicians were looking for some inherent self-contradiction, but the "absurdum" was never reached. It was discovered that this new axiom was perfectly tenable, and led to a new geometry of space that was curved and hyperbolic, in which the angles of a triangle added up to less than 180^{0} (see fig. 2.4). This

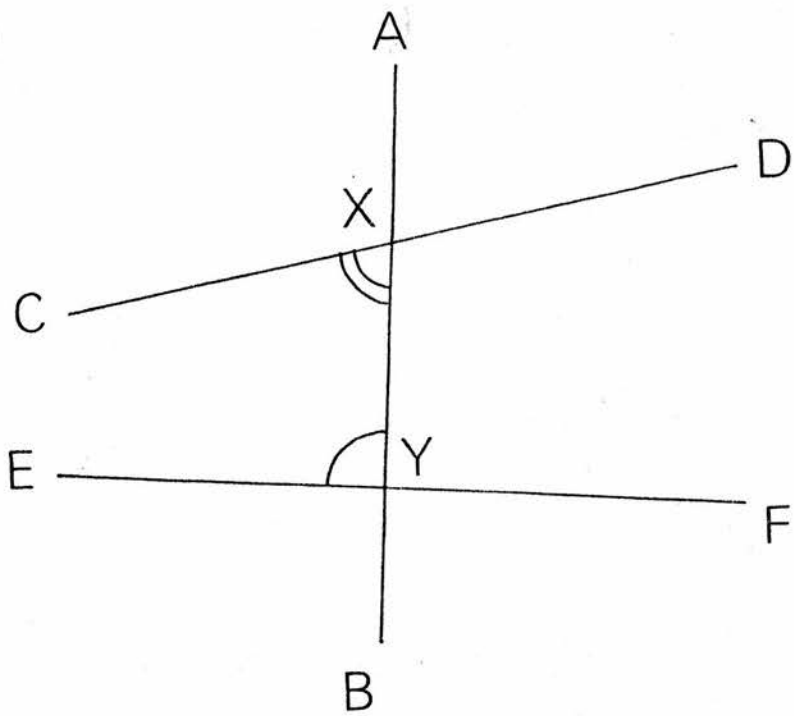


Figure 2.3

Euclid's Fifth Axiom:

The line AB cuts the lines CD and EF at X and Y respectively; the angles CXY and EYX add up to less than the sum of two right angles, so the lines DC and FE will meet when produced towards C and E. If CXY and EYX summed to 180^o, the lines CD and EF would be parallel and would not meet except at infinity; given EF, only one value of CXY will produce this, hence only one parallel is possible.

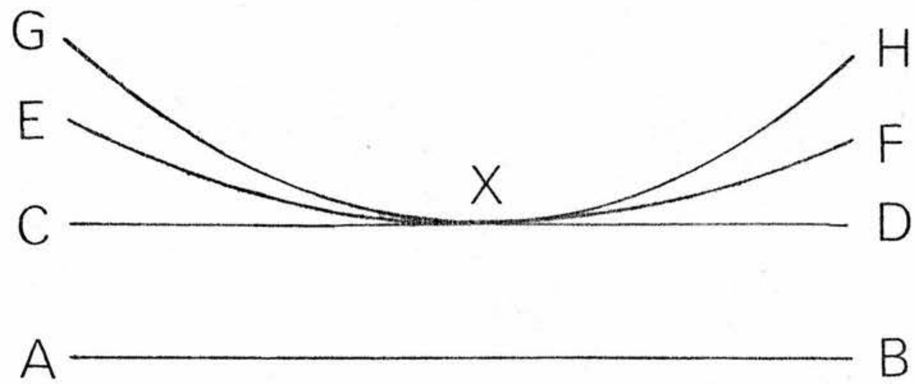


Figure 2.4(a)

Hyperbolic Geometry - CD, EF, and GH are lines through X all of which are parallel to AB. To be parallel they must therefore be "straight" in a space which is itself curved.

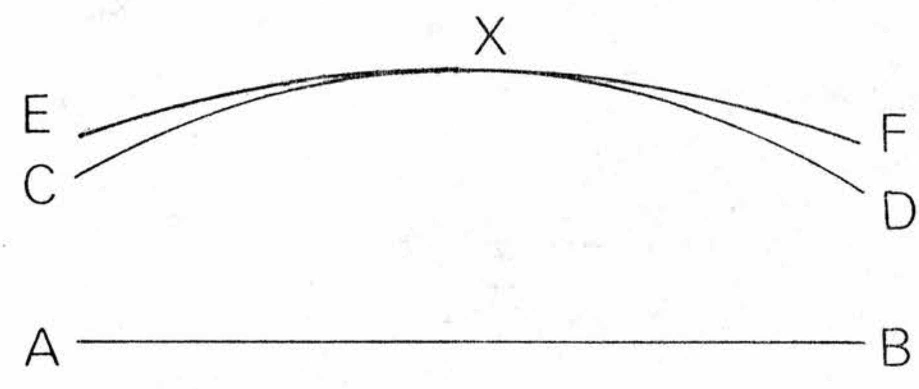


Figure 2.4(b)

Spherical Geometry - no line can be drawn through X parallel to AB, therefore lines CD and EF must cut AB somewhere. Since these lines are also straight, we must require the medium in which the lines are drawn, space itself, to be curved. Space must also be finite, for if it could be said that EF did meet AB but only at infinity, then EF would be parallel to AB by definition.

new geometry turned out to be completely consistent and congruent, as was the geometry the young and brilliant German mathematician, Riemann, constructed when he attempted a similar reductio ad absurdum proof based on the new assumption that no parallel could be drawn through the given point. This time the new geometry turned out to be curved and spherical, in which the angles of a triangle added up to more than 180^{0}. Riemann then constructed a systematisation of the new discoveries; Gauss had recently found that the shape of a curved surface could be described by the geometry upon it, and this led to the development of a system of curved spaces in which the curvature could be expressed by a single exponent; if this was constant and negative, a hyperbolic geometry was indicated, if constant and positive a spherical geometry, and if it was zero, the exponent described the old familiar plane geometry of Euclid. So just as Euclidean space can be as a subset of metric spaces rather than as inherently different, it can also be regarded as a subset of "Riemannian" spaces, produced by one particular value (zero) of the Riemannian curvature variable.

Previously, since Euclidean geometry was the only one that did not contain self-contradictions, it had gone virtuallly unchallenged. With the discovery of new congruence geometries there was new material for dispute as to which was the "true" geometry of space. So Gauss attempted to settle the matter by surveying a huge triangle formed by three mountains, the Brocken, the Hoher Hagen and the Inselberg, to see if he could detect curvature in the geometry so formed by demonstrating that the angles of the triangle did not add up to 180^{0}. This he failed to do, but this is not necessarily significant; just as there is very little observable difference between very small angles when the lines bounding them are short (yet when the angles are projected for long distances the discrepancy becomes more noticeable), so too, Euclidean and curved space behave in very much the same way over relatively small areas (such as Germany) yet anomalies might be detected over interstellar distances. Now, of course, it is possible to measure the parallax of distant stars, but the problem is still not solved. Rather than measuring space itself, both Gauss' and astronomers' experiments only tackle sensible measures of space, in this case light rays. So as Poincaré has pointed out, all these experiments can ever hope to show is the geometry of light rays, not of space. Establishing a Riemannian geometry of light rays would not be sufficent grounds for abandoning a Euclidean geometry of space, and would be no grounds at all if the latter were a more convenient assumption to make. Since space can only be measured in terms of light rays, rigid rods, etc., the geometry of space itself, divorced from these intermediaries, remains inaccessible. Consequently it makes no difference what geometry we assume to hold for space; the most convenient one (with regard to whatever process is being studied) is best:

" ...the axioms of geometry therefore are ... conventions. ... no geometry is either true or false ..." (Poincaré, 1900, pp 65, 73)

The geographical implications of curved space are perhaps less interesting than those of metric spaces. Apart from the obvious importance of spherical geometry to the geodesist and cartographer, It has been suggested that it might be possible to treat spatial interactions on the side of a hill as operative over a surface possessing a geometry of variable curvature. (Abler, Adams & Gould, 1971)

There is a temptation to regard Euclidean geometry as being somehow more "natural" than curved geometries; Kant specifically maintained that the only space that could be conceived of by the human intellect was Euclidean space; Helmholtz, however, has demonstrated this to be a result of the limited extent of mathematics and also of sensory physiology at that time (Helmholtz, 1968). Recent approaches to the subject have produced evidence to query the primacy of Euclidean space. The psychologists Luneberg and Blank produced experiments designed to test the geometry of visual space. (It is worth noting Helmholtz's remark that locality - and therefore space - is for us primarily a visual phenomenon; Helmholtz, 1968, p108). The problem that Luneberg encountered was that there is a natural tendency to interpret visual phenomena in Euclidean terms simply because it is so easy to use the various visual cues given by perspective and parallax to do so. So in his experiments he had to confine his subjects in a dark room in which they were presented merely with point sources of light to interpret. Given these extreme limitations, Luneberg did manage to demonstrate that the binocular nature of human vision gives to visual space a hyperbolic geometry of constant curvature - normally not detectable owing to interference from the interpretative faculties (Luneberg, 1947; Blank, 1958).

There is, however, another way in which cognitive space can be regarded as curved - should we find, for instance, that estimated distance between points tends to decrease relative to actual distance between points with increasing distance from the observer. In such a case, estimated distance would bear a curvilinear relationship to actual distance - a logarithmic curve. This is discussed at greater length in part III, especially section 5.

These then, metric geometry and curvature, are two of the more important properties that can be defined for space. A third one, that of dimensionality, we shall return to later by way of a conclusion. Next, however, we should consider again the model of spatial cognition presented in part I. If a cognitive space can be defined, it may be analysable in terms of the metric and curvature properties discussed above. These, though, will be properties of that cognitive space and will not in themselves tell us anything about the formation of the cognitive space. Implicit in the action of the "geographical variables" in fig. 1.2 was the distortion of real distance being caused by properties of that actual distance - properties related to the nature of that particular space. And since that distance is a part of space itself, it is ultimately the nature of space itself that will lend itself to the operation of distortionary processes in the cognition of space. In order to examine other properties that may or may not be important, it will perhaps be best to consider the discussion of the nature of space in a historical context.

2) THE HISTORY OF THE DISCUSSION OF SPACE

(i) Absolute and Relative

Geographers and psychologists are by no means the first to consider space in terms of perception. Indeed, the use of the term "perception" in a philosophical context may recall to many the famous dictum of Berkeley, that the "esse is the percipi" - and indeed, for that celebrated bishop it was space as perceived that was important, and, as space can only be perceived by means of relationships, this brought him into opposition to the absolutism of Newton. These two positions, easily represented as polar opposites, were actually more a matter of different emphasis. The contrasting ideas, that space is an absolute and invisible entity in its own right, a setting for spatial relationships which it must precede a priori (as Kant maintained), on the one hand, and that spatial relationships are derived from material phenomena a posteriori and build up a pattern of space relative to those phenomena, on the other, both had to be conceded as reasonable by either side. Neither side could really deny the existence of the "other sort of space", at least as a philosophical thesis. One senses a sort of philosophical snobbery when Newton writes:

" I do not define time, space, place and motion, as being well known to all. Only I must observe, that the common people conceive those quantities under no other notions but from the relation they bear to sensible objects. And thence arise certain prejudices, for the removing of which it will be convenient to distinguish them into absolute and relative, true and apparent, mathematical and common." (Newton, 1934, p.6)

He has to concede that relative space exists:

"But because the parts of space cannot be seen or distinguished from one another by our senses, therefore in their stead we use sensible measures of them ... And so, instead of absolute places and motions, we use relative ones; and that without any inconvenience in our common affairs; but in philosophical disquisitions, we ought to abstract from our senses and consider things themselves... "(Newton, 1934, p.8)

Berkeley, one feels, sees the point of this quite clearly but is more of a pragmatist; relative space takes on a greater importance by being more of a real space rather than an intellectual space. If there was only one body in the universe it could not be moved; according to Newton it could, but even so, as there would be no way of distinguishing between the isolated body moving and the body at rest, there is little point in constructing the idea of absolute motion. And if all bodies were annihilated there could be no motion at all, for sure, and therefore no space at all; either that or completely empty space, exclusive of all body which "seems impossible, as being a most abstract idea." (Berkeley, 1938, para. 116)

But even if Newton allows some form of relative space, he still insists on being rigorously scientific about it; a relative space that incorporated perceptual distortions into its very framework would doubtless have shocked him as being very base indeed. It is the physicist who establishes relative space by careful measurement - he still has to use his senses to do so, hence the relative element. He can establish that A and B are 2.47m apart, and in this case, "absolute and relative space are the same in figure and magnitude". A and B are both relatively and absolutely 2.47m apart. The difference is that whereas B is not moving relatively to A, it is hurtling through absolute space at some phenomenal speed thanks to the movement of Earth, Sun and Milky Way; either that or it is stationary in absolute space and all other bodies that appear to be moving are performing elaborate gyrations with respect to it. Were the latter geometrically possible, it could not be totally ruled out without recourse to Occam's Razor.

Berkeley, however, allowed relative space to be:

"the immediately sensed spatial extension of sensed data (which is a purely private space, varying with the degree of one's astigmatism or the clearness of one's vision)" (Berkeley, 1938, para.116) which is a step towards the 20th century philosophers influenced by psychological studies, and the psychophysicist who merges gradually with the behavioural geographer. By way of illustration, depth has no significance at all as a concept, according to Berkeley (this is, of course, depth as the third dimension of a three dimensional object rather than the common usage of depth as of, say, water). Depth can never be perceived as such, being only breadth seen from the side. God, being everywhere, would see everything perfectly as breadth, and thus the concept of depth would make no sense to Him.

With the introduction of perception as an element in relative space, a note of anthropocentrism has crept in. This reaches perhaps its fullest sense in the phenomenological writings of Merleau-Ponty, where space is seen not only as relative but relative to man alone. Space is acutely tied up with the manner of its observation, and thus the most important spatial relationships are those couched in the form of "towards the observer" or "away from the observer" since this is the way space is generally perceived. The sensation of space is achieved through the medium of the human body and so the spatiality of the body itself becomes of great importance, as well as the position of the body in space. Anthropocentrism is taken to the extent that relationships such as "the book is on the table" can only be posited by pre-reflectively associating oneself with either the book or with the table and then comparing the relation of the other body with oneself. Otherwise "on" becomes indistinguishable from "under" or "beside". (Merleau-Ponty, 1962)

The significance of this should not be underestimated in a study of cognitive distance. If we ask an observer to estimate the distance from himself to a distant place, well and good. But if he is asked to estimate the distance from one distant point to another, to what extent will the distance between himself and the two distant points affect the extent to which he can identify with them, and affect his judgement of the distance? These are unknown variables.

(ii) Space and Divinity

When we allow space to be a result of perception, it is of course the perception of matter that is in question. And here, curiously enough, the absolute/relative controversy heads into another dichotomous position, the spiritual/temporal. The absolutist asks the philosopher to elevate himself from wordly considerations and contemplate that which is without material aspect, is infinite, immutable, in fact somewhat resembling the Divinity. This was not lost upon a number of philosophers, among them Newton, who, though he talked about absolute space in terms of a Divine "Sensorium" (Newton, 1952, p.403), appears not to have intended too close an association between space and God to have been made. (Clarke, 1956, p.11)

But for people like the English scholar Jacob Raphson, writing in 1702, and the 17th century Cambridge Platonist Henry More, the similarity was more important; the very unmaterialistic nature of absolute space but the very real nature of extension made the linking of the spatial and the spiritual an excellent demonstration of the reality of God, and a weapon against, inter alia, the Greek Atomists, whose materialism More found too atheistic. (Jammer, 1954)

So (from the geographer's point of view) here we have a new twist to the position; we have assumed so far that space, as a sublunary and material phenomenon, is a suitable topic for study by geographers. But it would be a brave geographer who sought to bring the Divine within the measuring sticks of his discipline. If space and God are directly equatable, we might have to revise our plans to make the nature of space part of our geographical theories.

The English were not the first philosophers to seek to equate space with God. Jammer traces the idea right back to 1st century Judaism where the word "place" (makom) was also used as a name for God (Jammer, 1954). Jammer admits that this was quite likely to have been no more than an abbreviation for "holy place" (makom kadosh), but whatever the origin, it was a convenient theme for a theology seeking the abstract above the material, and fitted in nicely with Psalm 139. Jammer then attempts what appears a somewhat tenous line of connections, through the Cabala, all the way to Newton via the early 17th century Calabrian writer, Tomaso Campanella. To quote Jammer:

"In Campanella's conception, space becomes an absolute, almost spiritual entity, characterised by divine attributes." (Jammer, 1954, p.33)

On the other side of the coin is the relative space that in comparison seems almost sordid: a a jumble of relationships between bodies of base matter imperfectly perceived through failing material senses... surely no philosophy fit to stand beside the lofty aspirations of the absolutists? But in fact this material emphasis is not so atheistic as More felt it to be. Berkeley was particularly anxious to put down theological space as being itself a potentially atheistic philosophy. By identifying God with space the Platonists thought to show the reality of God even as space is real, but Berkeley saw that this also threatened the unreality of God should absolute space turn out to be unreal. The concept of absolute space was not secure enough to be used as a theological anchor, rocking, as he felt it to be, under the strain of his arguments already quoted, and he preferred to elevate God above space altogether.

A side track on the issue of the divine associations of space is the identification of space with light - another attempt to find a phenomenon in terms of which space might be illustrated. Jammer adduces several examples of deific associations with light (some of which are obviously metaphorical as in "lux mundi") and looks for a pattern of space/light association running parallel to the space/God philosophy (Jammer, 1954). One of the most interesting examples (not so directly deific as some of the others) is that the first act of creation in the Book of Genesis is the creation of light, not of space. And if Kant was right about the primacy of space... The argument is obvious, but unfortunately Genesis also details certain waters which were never specifically recorded as being created; if they got there, then space could presumably appear in a similarly undocumented fashion.

Too close an identification of space with light leads to obvious difficulties in matters of sealed boxes and suchlike, and this and similar excursions into divinity are by and large more suited to the mystic than the philosophical geographer. This brief discussion of divinity and light has been included largely for the sake of completeness; the two ideas do not lend themselves to further development in a geographical context.

(iii) Space, Place and Matter

The theory of relative space, of space as a system of inter-relationships between material phenomena, does suggest important ideas relating to the structure of perceptual space. If we are seeking insight into the nature of space at a perceptual level, we are looking for those properties of space that dictate the differentiation of spatial location or spatial position to the senses. We may have a relative space that is in fact an aggregate of spatial relationships which are themselves a function of particular perceptual parameters. The structuring of this perceptual space will depend on the nature of these crucial parameters. In the words of Helmholtz:

"An object's appearance at a certain definite place and not at another must depend on the nature of the real conditions which produce the idea. We must conclude that other real conditions would have had to exist in order to cause the object to be perceived at another location. Therefore in the real world, conditions or complexes of conditions must exist which determine the position in space at which an object appears to us." (Helmholtz, 1968, p.244)

These conditions Helmholtz calls topogenic factors.

"We know nothing about their nature; we only know, that the occurence of spatial differences in perception presupposes difference in the topogenic factors." (Helmholtz, 1968, p.244)

Now, in an ideal absolute space, the only topogenic factors would be purely abstract geometrical relationships. The factors which cause a certain point to appear to be a certain distance away are limited to the fact that that point actually happens to be that distance away. But in terms of a perceptual space, the matter is obviously more complicated. An object placed in a specially constructed room in which the irregular angles of the walls give false perspective cues appears to be much closer or further away than it really is. If space is dependent on the relationships between objects, then the nature and the placing of these objects should constitute topogenic factors. Relative space is largely made up of intervals; the German mathematician Cantor produced a proof showing the equi-cardinality of all positive intervals independent of length; (all positive intervals are, as it were, topologically equivalent) according to Grunbaum, this suggests:

" ...there is no intrinsic attribute of the space between the endpoints of a line segment AB, or any relation between these points themselves, in virtue of which the interval AB could be said to contain the same amount of space between the termini of another interval CD not coinciding with AB." (Grunbaum, 1963, p.10)

The direct implication of this is that the perception of any geographical distance would be a function of the number of intervals between perceptual events contained within that distance; the presence of an object C between the observer A and the object B is a topogenic factor relating to the position of object B which is "beyond C". (See fig. 2.5). If further objects, C_1, C_2, C_3 and so on are added to the line AB, the number of spatial relationships and therefore the amount of space, at least of perceptual space if not of absolute or Euclidean space, is theoretically increased. Perceptual geometry becomes the study of relations and not of space defined by means other than of relations; and number supercedes magnitude in importance. This is Maxwell's dictum that: "We cannot describe... the place of a body except by reference to some other body" in an extreme form. (Maxwell, n.d., p12)

Another possible direction of thought is the increasing association of space with matter itself, and this, as will be seen, may be of particular importance to the geographer. The material components of any distance are of natural interest to the geographer, and if these affect spatial cognition significantly, it will greatly

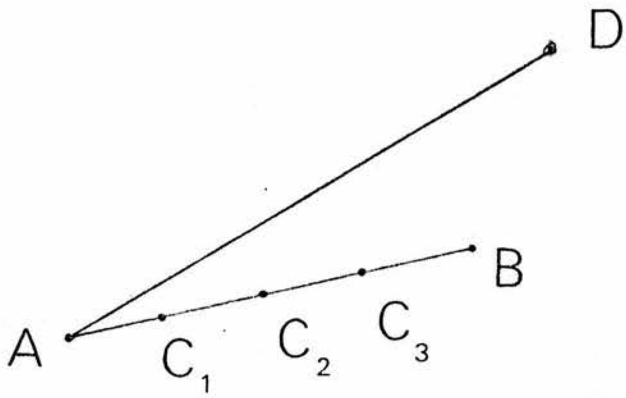


Figure 2.5

Interval or Event Space - the line AB is four units long and therefore longer than AD which is one unit long, even though the single unit is longer than AB when measured in Euclidean terms.

facilitate the arguments for a geographical approach to cognitive distance. How strongly this relationship between matter and space is to be emphasised is a matter of some divergence. In the above arguments there is no need for the space under discussion to be actually occupied. The definition of a section of space may depend on the bodies surrounding it, but the space itself may be empty. But when one maintains, as Leibniz did, that empty space is purely imaginary, and that the vacuum of Guerike and Toricellus is a chimera, then the relationship between space and matter is a much closer one. Leibniz identified his position:

"I don't say that matter and space are the same thing. I only say, there is no space, where there is no matter; and that space in itself is not an absolute reality. Space and matter differ, as time and motion. However, these things, though different, are inseparable." (Leibniz, 1956, para. 62)

But to Descartes, the relationship was closer still. He argued on the theme of the extension of bodies; the distinguishing feature by which we acknowledge a phenomenon to be a body is not hardness, colour nor heaviness but only its extension. A body is only a body when it occupies a space, so:

" A space, or intrinsic place, does not differ in actuality from the body that occupies it... " (Descartes, 1959, para. 10)

Extension is seen as the distinguishing feature of both space and matter:

"It is easy to see that it is the same extension that essentially constitutes a body and a space; that there is no more difference here than there is between the essence of a genus or species and the essence of the individual." (Descartes, 1959, para. 11)

And this, of course, makes a vacuum logically impossible:

extension of space is identical to extension of body, therefore the extension of nothingness or "no body" (when anything which possesses extension is by definition body) is wholly contradictory.

Of significance is Descartes' use of the word "place". He distinguishes between place and space in a manner somewhat akin to the qualitative/quantitative distinction. The volume of a stone (or the extension thereof) indicates how much space it occupies; if the stone is moved it retains its extension and occupies the same space; it no longer occupies the same place (position), which is invaded by some other body, or by air, which, though it may be said to occupy the same place as the stone did, may not occupy the same space. Though we may say that the Belfast City Hall was built in the same place as the old Linen Hall, the new building, the re-placement of the old one, being larger and of different design, occupies a different (and larger) space.

Descartes further divides place into intrinsic and extrinsic place, either of which may be considered with respect to a particular body. Intrinsic place turns out to be identical to space: the place of a body is "where it is" relative to itself, i.e. its extension, i.e. its space. Extrinsic place is the neo-Aristotelean bounding surface of the body; which, it is important to note, is not part of the body itself, nor part of the surrounding body or bodies, but is the infinitely small juncture between them. This clears up the old problem of the "motionless" boat going upstream as fast as the river flows down; the boat's place is continually changing if we regard its extrinsic place as being part of the water (the interface between the boat and the water); but if we abstract the bounding surface we can more sensibly regard the place as constant. But in fact we still have to regard it as being constant with regard to something else.

"To determine the position we have to look to some other bodies, regarded as unmoving; and we may say - relatively to different sets of bodies - that the same thing is simultaneously changing and not changing its place." (Descartes, 1959, para. 13)

Eventually " ... we shall ... be deriving the determination of place from some unmoving points in the heavens. But we may well end by thinking that no such genuinely are to be found in the universe... ; and in that case we shall conclude that no object has a permanent place except by the determination of our thought." (Descartes, 1959, para. 13)

There is in Descartes' writing on space and place a certain similarity to Aristotle (despite Descartes' aversion to scholastic philosophy); but for Aristotle the notion of place was more important than that of space, which becomes merely a vague aggregate of places. With the "abhorrence of the void" the universe must be a plenum and space must be coterminous with matter. The fact that the universe and therefore space is finite is, in Jammer's phrase, "an accident of matter". (Jammer, 1954, p.20)

While Aristotle's views were the most enduring, there were other thoughts on the nature of space in ancient times. Aristotle's pupil Theophrastus appears to have been one of the first to propose a theory of systematic relations with regard to space; (Jammer, 1954) elsewhere there were notions of space as a primordial atmosphere, a necessary precursor to existence, after the Kantian manner. Space was something in which you could put things, a universal container, and for the Atomists, void.

"All nature then, as it exists, by itself, is founded on two things: there are bodies and there is void in which these bodies are placed and through which they move about." (Lucretius, 1886, III, p.23)

Thus Lucretius. Furthermore, space must be infinite, for, were it finite, and a man stood at its furthest extremity, and hurled a javelin outwards, where would it go? And also, since Lucretius does not understand gravity, it seems evident to him that if space were finite we should have fallen to the bottom of it by now.

Of course, the boundary of Aristotle's finite universe is like the boundary of an Einstein-Riemann finite universe (a space of constant positive curvature must be finite) - it is a boundary, as it were, with only one side, and at the edge of the universe "outwards" does not exist - there is simply no such direction. Beyond it there is not even nothing, there is no beyond. Sellar and Yeatman (1932) neatly parody Einstein: space is curved and finite, and if you keep on going you eventually bump into the back of your own head.

To Newton space was infinite and isotropic. To Aristotle it was finite, to Lucretius it was anisotropic (possessing the direction "down" - owing to the imposition of a primitive concept of gravity). One may feel that Newton's position is the more "natural", but the other two serve at least as illustrations of the fact that, in order to keep an open mind on the subject when we come to regard the nature of perceptual space, even what we may regard as elementary assumptions can be, and may need to be discarded.

If we attempt to define space in terms of place we cannot easily escape Swinburne's definition of place ("a place is identified by describing its spatial relations to material objects forming a frame of reference") and a circularity is reached. (Swinburne, 1968, p.13)

However, the above disquisition on space and place is important. We are beginning to piece together two quite different attitudes to space. On the one hand we have space conceived of as an infinite ethereal container, absolute and unvarying. On the other, the idea that space can be defined in terms of the things that it contains. These may be what we have loosely termed "perceptual events", intervals, some form of division, or they may be material things, or the places of material things.

We can very approximately put Newton, Kant and Lucretius in the first camp. In absolute space geometry is regular and probably (but not necessarily) Euclidean. In the second camp we find Berkeley, Descartes and Aristotle appearing as unlikely bedfellows. It should be pointed out, since these three philosophers really are very unlikely bedfellows, normallly characterised as fundamentally opposed to one another, that this association only occurs because of the particular theme being followed. Though the philosophies these three represented are very different, the effect, from the point of view of the geographer studying space, is very similar. Though Berkeley and Descartes might have disagreed on the objectivity of space, the geographically important theme of the close relationship between space and its contents is there in both. For different reasons, perhaps, but it is still there. Associated with the second position is a geometry of relations, not of absolutes. Space is finite if matter and place are finite, and its properties are apprehended by way of the properties of the contents of space.

In terms of our perceptual study, two corresponding positions appear. We can hypothesise that space will be cognised in absolute terms, or in relative terms. If the latter is true, we might expect properties of cognitive space that are a result of the cognition of the contents of that space. For instance, we have already mentioned a hypothetical exaggeration of space close at hand relative to far away, and a corresponding power function relating cognitive to physical distance. This was given as an example of curved space, but one could also interpret it this way: that as familiar areas contain more (cognised) places than unfamiliar ones, familiar places occupy more space. More places, the more space needed to hold them.

(iv) Space and Time

God, light, matter, place, all have been the subject of attempts to find a parameter by which space can be defined. There is, of course, always the unpleasant possibility that no such parameter exists, that space cannot be described in terms of anything else and therefore cannot really be defined. We can say that length is defined by measurement with a rigid scale, and then define a rigid scale as one which always keeps the same length. These circularities are hard to avoid. The last attempt to understand space in terms of something else that we can look at here is the association of space with time. And this, perhaps, is no longer a search for a simple definition of space, for time is as problematical a phenomenon as space, if not more so. Rather it is, since philosophy is by and large more disingenuous than it used to be, a linking up of two difficult questions in the hope that they may shed some light on one another. But before discussing at length the arguments that lead up to the space/time analogue, it will be worthwhile to consider the more mundane aspects of the matter.

Conventionally we tend to think of miles and kilometres as being spatial measures, and of hours and days as being purely temporal ones. This is an educated viewpoint, even an academic one. To primitive man, the position was different. The length of a journey in miles was not relevant to him; one mile of plain and one mile of mountainous terrain are very different quantities from an experiential point of view. However, the experiential (that is, the important) effects of distance could be quite adequately measured and expressed by the use of temporal units in the place of purely spatial ones. If a journey was three days long, that was sufficent knowledge. The traveller then knew when he would arrive, how many nights he would have to sleep on the road, and how much food he would need on the journey. How many miles the journey involved was of no consequence in comparison. Such measurements were irrelevant, and the irrelevant tended to get left out. So the Eskimos made maps for their own use which showed direction graphically, and distance by marking thereon of a number indicating the number of days' travel each journey might take. For the Eskimos this was a functional arrangement; but one can see in it an implicit philosophical statement: that space is a function of time.

Even in contemporary Western society, where signposts and maps are all in miles or kilometres, one still finds a "how far?" question getting a temporal answer. It has to be regulated with regard to different modes of transport possible, true, but the greater relevance of temporal information, particularly in a world increasingly temporally-oriented, overrules the logical objection that a temporal answer strictly should demand a "how long will it take?" question. One also notes that metric experience of distance is harder to come by as regards miles travelled unless (as was briefly discussed in part I) one has a habit of watching car milometers, or of carrying a pedometer. The temporal extension of a journey, on the other hand, is easily measured with a pocket watch or even by observation of the passage of the sun. Furthermore, one notes that we use essentially similar adjectives to refer to both spatial and temporal extent: a "long" time and a "long" distance, for example.

Now, if this link between the temporal and the spatial does exist in everyday reckoning, and if it is true that a degree of priority adheres to temporal measures, this may give us a parameter by which we may find space being perceived. It is possible that the perception of the length of a space traversed by a subject is influenced by the time it takes him to traverse that space. Thus given an equal length of motorway and mountain track, the mountain track should appear the longer distance since it takes longer to travel along. Obviously, the subject is well aware that he travels at different speeds along the two distances, and that he will necessarily take longer when travelling more slowly, but that is no indication that he would be able to make sufficent allowance for this when estimating the two distances. It is by no means uncommon for someone walking for the first time a distance which he had frequently driven along to dicover that the distance was "longer than he had imagined".

The concept of dimension is an important one. We are accustomed to using the word to mean size, which is equivalent to extension, which is spatial extension, and, more particularly, extension in a particular direction. The directions are distinguished by the condition that each "dimensional" direction must be at right angles to all other dimensional directions. Spatial description increases with increasing dimension. At the lowest level we find zero dimension or no dimension; a point, which has position but not magnitude. One dimension, and we can talk about distance. With two dimensions comes the plane surface and the description of area. With three the solid and volume. And there it seems to stop. We can only draw three lines all mutually perpendicular, and for this reason the contention that three and only three dimensions exist in reality was for a long time accepted as fact. However, in mathematics one can add any number of extra dimensions, albeit in an artificial manner. This can easily be illustrated with reference to the game of chess.

Chess, or at least, variations on the game, covers a wider dimensional range than is generally supposed. Admittedly, it would be difficult to produce zero-dimensional chess, which would have only one piece and no possible movement. However, one-dimensional chess does exist, and is played on a board 27 squares long and one square wide (Parton, n.d., p.1). A rook (an orthagonally-moving piece) can only move in one possible direction from a corner (end) of the board. Ordinary chess is, of course, two-dimensional, being played on an 8x8 board, and a rook in the corner of the board has two ways to move, along the rank and along the file. Three-dimensional chess, so beloved of novelists, with the addition of extra boards tiered one above the other, gives the rook three distinctly different directions in which to move. The game does exist independently of fiction, and in its standard form is played on four 5x5 boards arranged in cuboidal fashion (Dickins, 1969, p.16). But another game that also exists is the extremely taxing four-dimensional chess, in which the rook has four possible directions in which to move. The extra dimension is accomplished quite simply; four three-dimensional "boards" are arranged in a row, and moving from a square on one set of boards to the equivalent square on one of the other sets of boards constitutes the fourth move available to the rook. The whole playing area, or four-dimensional board, is a 5x5x4x4 grid (also termed a "space hyper-model"; Dickins, 1969, p.18). To obtain a game of five-dimensional chess, all that would be necessary would be to arrange twelve more three-dimensional sets in three more rows, to give a 5x5x4x4x4 "board" (see fig. 2.6). And so on. The mathematical multiplication of dimensions in this manner is potentially infinite.

Nor is this the only way of producing higher dimensions in mathematics. Another device, instead of multiplying the the axes of conventional co-ordinate geometry, introduces co-ordinates for phenomena other than points. Using only two conventional dimensions, it is possible to construct a three-dimensional manifold of circles where each circle is defined by (x,y,r) - the co-ordinates of the

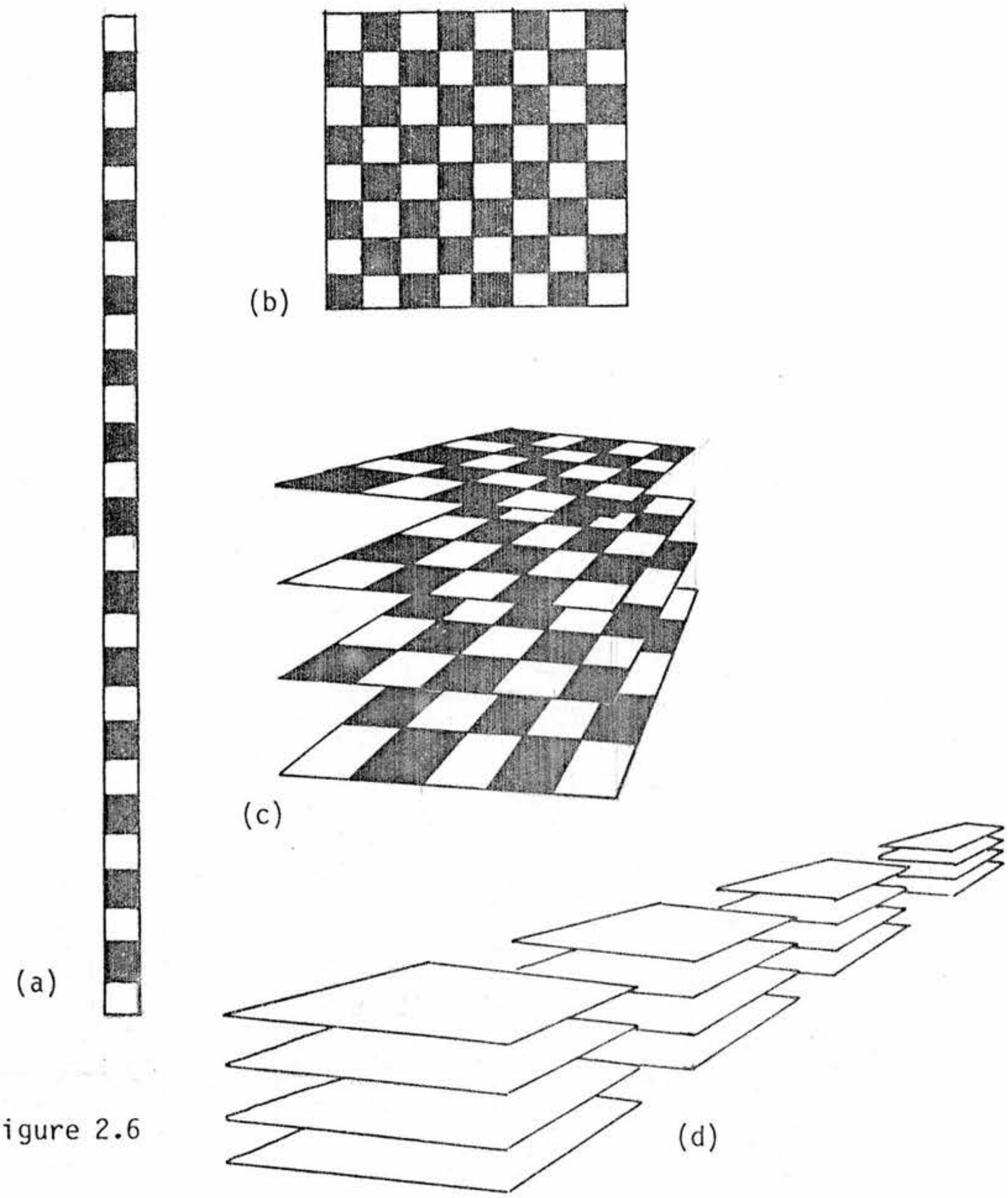


Figure 2.6

Boards for playing:

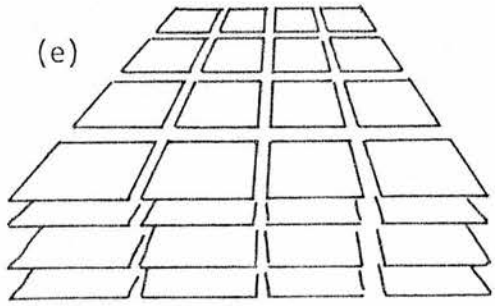
(a) One dimensional chess

(b) Two dimensional chess

(c) Three dimensional chess

(d) Four dimensional chess

(e) Five dimensional chess



Squares are not shown in (d) and (e)

centre, and the radius. Similarly, a four-dimensional manifold of ellipses given by (x,y,r_1,r_2) can be drawn. From there it is easy to visualise a six-dimensional manifold of "flying saucers" represented in three conventional dimensions by (x,y,z,r_1,r_2,r_3).

To return to the four-dimensional rook, it is still valid to ask whether or not the four different moves are really four different dimensions. It is obviously essential to sort out one's definitions. This we shall attempt to do by means of two syllogisms.

First Syllogism

All dimensions are at right angles to one another.

All directions mutually perpendicular cannot be expressed in terms of one another. (This is simple vector analysis.)

The vector x cannot be expressed in terms of another direction. (The 4D rook's move, treated as a vector, possesses this property.)

Therefore, x is not necessarily at right angles to all other directions and is therefore not necessarily a new dimension.

Second Syllogism

A dimension is a direction which cannot be expressed in terms of any other direction.

All directions mutually perpendicular are inexpressible in terms of one another.

Therefore all directions at right angles to one another are dimensions, but not all dimensions are necessarily at right angles to one another.

The two syllogisms use slightly different definitions, but if one uses the second definition, the first conclusion of that syllogism comes very close to the spirit of the original definition. Consequently it is possible to view the second definition as being more flexible and therefore potentially more fruitful for the geographer interested in space and cognitive space. And if the four dimensions we have here engendered are not strictly at right angles geometrically in that one cannot take a protractor to the fourth rook move as you can to the other three, one can still think of all four as being at least "metaphysically perpendicular".

So far, so good; we have more or less arrived at Riemann's general definition of space as an "n-dimensional manifold". Three of the dimensions we label length, breadth and depth, but can we make any more sense out of higher dimensions other than row piling on row of multiplying chess boards?

The fourth dimension at least, may be susceptible to some sort of concrete identification. (Obviously, we are not too likely to deduce the "nature" of the 103rd dimension. The number of "real" dimensions may be greater than three, but it is not necessarily infinite.) Of passing interest in this context is a passage in E.A. Abbot's "Flatland" (Abbot, 1926) where "A. Square", the hero of this tale of a two-dimensional world, meets a visitor from the three-dimensional world, to wit, a sphere. Now, the square possesses only two-dimensional senses, and can in no way directly perceive the third dimension, and furthermore, he is quite incapable of conceiving of it, as well. To him a third dimension is quite impossible; for a start, he muses, only two lines can be perpendicular to one another (!), therefore - only two dimensions can exist. As the sphere passes up and down through the plane on which the square lives, it takes the attributes of a circle of changing radius (since this is seen end on, as it were, it appears as a line of changing length). This seems strange, but is still two-dimensionally possible. However, when the sphere leaves the plane and then lightly descends upon the square's interior, a spot inaccessible to two-dimensional manoeuvres (unless the square's sides be breached), the square is forced to concede the existence of another dimension imperceptible to him. (Thus enlightened, he asks the sphere about the fourth dimension, to which the sphere, no more broad-minded than the square was initially, gives an off-hand dismissal.)

Now, one of the most significant points in the story is the way in which the three-dimensional sphere appeared to the two-dimensional square (possessed, of course, of only two-dimensional sensory equipment); that is, as a series of cross-sections, the expanding and contracting circles being cross-sections of a larger continuum extending into this strange new third dimension. This does have its equivalent in our three-dimensional world (we possessing only three-dimensional sensory equipment). If one considers the history of the world as a whole, then surely this is never perceived directly in its entirety; we only see a series of cross-sections across it, each a fraction of a second in duration. We cannot see the whole history of an object at once, just as the square was not able to see the whole of the sphere at once. By this analogy, we can begin to think of duration as being in the nature of a new direction, and approach the concept of a fourth dimension which is not so much time in the layman's sense, but extension over time, or space-time.

In terms of the example just given of four-dimensional chess, the array of boards can be seen as a representation of the life history of one 3D "board", seen at time 1 (just after its creation), time 2, time 3 and time 4 (just before its destruction). This is what Minkowski (1923) called the "world-line" of an object; Hagerstrand (1963) has used the phrase "life-line" to describe more or less the same thing in a geographical context, since the concept lends itself to the geographical description of spatial processes. The world-line of a human being would be comprised of all the positions which that human ever occupied strung out in sequence like a long pink tube (baby-width at one end, adult-width the other), which at any point could be intersected by the plane of an instant resulting in a three-dimensional object, the human being at that instant. This intersection phenomena is in fact a property of dimensions; the intersection of three-dimensional solids gives a two-dimensional plane, and so forth (see fig. 2.7). Similarly, two lines, when "joined" together, trace a plane; two planes imply a solid between them, and two solids, say two identical cubes temporally separated, could similarly be joined by tracing the pattern of movement of one cube to the position of the other, tracing out the four-dimensional world-line of the cube in the process.

It is important not to think of time as being something moving; if time really did "pass", it would have to move at a speed, and speed is given by the formula distance over time, and what time can one measure the passage of time against? Time itself must be static, a fourth co-ordinate in a map of the history of the universe, a map across which stretch all our world-lines.

The distance that separates Edinburgh from London is not merely spatial in a three-dimensional sense, for if I am in Edinburgh now, it is quite impossible for me to reach "London now". The best I can do is to visit "London six hours hence", which is a slightly different place. In the course of my travelling, I alter all four space/space-time co-ordinates; the distance which separates the two cities, and therefore the space also, is essentially four-dimensional.

However, if time is to be accounted as a fourth dimension, it will be necessary to show that it is essentially similar to the other

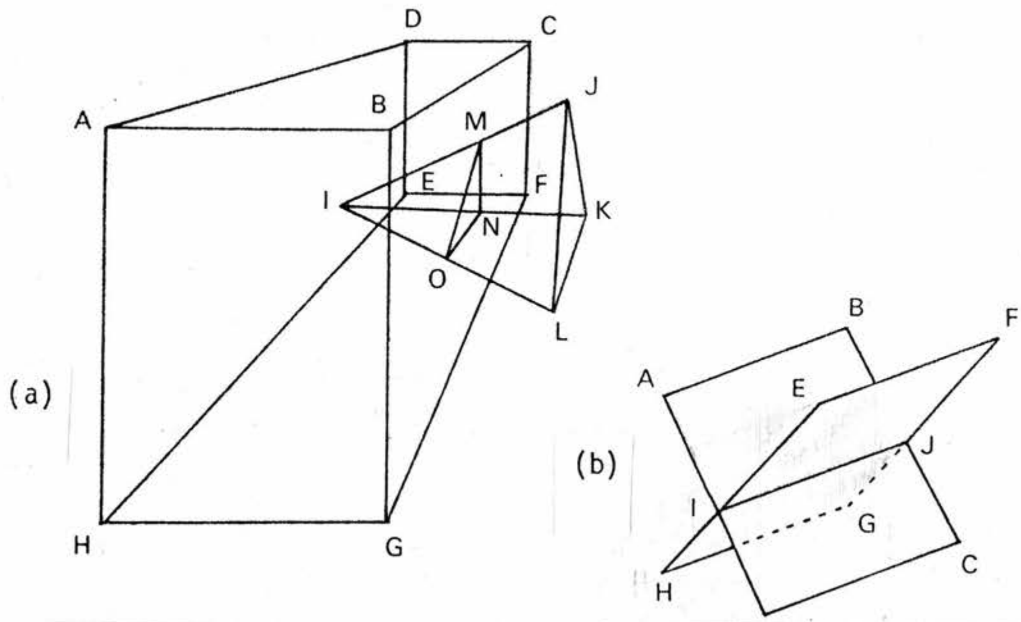
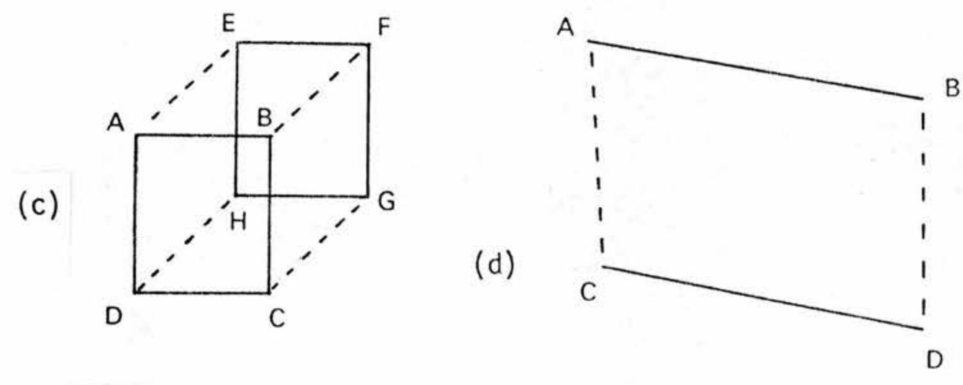


Figure 2.7

(a) Two solids, ABCDEFGH and IJKL, intersecting to give a plane, MNO.

(b) Two planes, ABCD and EFGH, intersecting to give a line, IJ.



(c) Two planes, ABCD and EFGH, being joined to give a solid, ABCDHEFG.

(d) Two lines, AB and CD, being joined to give a plane, ABDC.

three; space and time must be shown to be valid analogues. This has been quite well accomplished in a paper by Richard Taylor (1955), who argues that objections to this analogy do not hold water. For example, the argument is quoted that a thing may be in one place at two different times, but never in two different places at one time. The answer to this is that a thing can occupy a single place at two times if it occupies that, or another, place between the two given times. Otherwise it ceases to be the same object. Similarly, an object may occupy two places at the same time under the same proviso, viz that it occupies some place between the two given places. One end of a book occupies a slightly different place from the other end, but the book as a whole must occupy space continuously between these two ends.

One or two other common objections to the correspondance are not dealt with by Taylor, but on examination they also must yield. Mention has often been made as to how one can "predict" the past but not the future in matters of temporal consideration, whereas no such spatial discrepancy exists. Actually the positions are very similar. I can predict certain things about the future given certain assumptions of the absence of change. I can predict that three weeks hence there will be a map hanging on my wall, because it is there now and I have no intention of removing it. It may fall down of its own accord, of course, in which case the prediction will be wrong. I can make similar spatial "predictions" about the world "now" subject to the same limitations. I can "predict" that a certain tree, many miles away, exists at this precise moment, based on the evidence that it was there when I last saw it. Of course, it may have been blown down or cut down since, in which case the "prediction" is wrong. We can make 100% certain "predictions" about the "immutable" past only if we have some way of remotely sensing the events we wish to pronounce on. Similarly, we can make accurate statements about the present state of spatially distant objects only if we can garner evidence about them by means of "live" television broadcasts and the like.

Another objection, that time is irreversible, is based on the misconception that time somehow flows. Space too is irreversible if one must use the word. How can space ever be reversed?

The interpretation of space in terms of time, particularly as a feature of perceptual space, thus becomes a natural process something akin to thinking of length in terms of breadth; it is an association of two parameters of what is essentially the same thing: the four-dimensional continuum. We can measure space in terms of time as the Eskimos did; we can similarly measure time in terms of space as when we talk about Cromerian, Anglian, Hoxnian and Walstonian periods - measurements of Quaternary time which are defined relative to the spatial extent of ice sheets. In fact, to use an ordinary clock is to measure time by the space traversed by the hands. Where temporal substitution becomes a distortionary feature in perceptual space is where it is used inconsistently. In space-time London is closer to me than Belfast is (since I can't afford the air fares); but I know that in Euclidean 3-space, Belfast is the closer of the two. If I did not know that from indirect sources, I might make an incorrect judgement as to the relative positions of the cities in Euclidean 3-space which I should then place with other comparisons in 3-space which might be perfectly accurate. If all my judgements were based on time estimates, an arguably accurate (or at least, consistent) account of the spatio-temporal relationships of the points under question would be obtained. But when the perceptual process uses both four and three dimensional estimates together, a perceptual space is developed which has 4D elements without being accurate to either 4-space or 3-space.

The third dimension, according to Berkeley, is really the second dimension seen from the side. As two dimensions, they are therefore similar, and, from a perceptual point of view at least, interchangeable. If we find that the perception of distance is significantly affected by temporal considerations, that will be considered as evidence for dimensional substitution; it will be dimensional substitution we shall invoke to explain the phenomena.

(v) The Fifth Dimension

Something of the indeterminacy of Riemann's definition now appears more clearly: "n-dimensional manifold" can, in a realistic rather than purely mathematical sense, refer to values of n=3 or n=4. It now becomes tempting to see if any interpretation can be put on the fifth dimension; success will give us another possible dimensional substitution for consideration. The concept of the fifth dimension has received very little discussion as such; there is an interesting examination by Reichenbach of what the world would be like if colour were the fifth dimension, but this is not intended to be strictly relevant (Reichenbach, 1957). The following speculations are purely tentative; they have no mathematical basis and the reader may make of them what he likes.

Firstly, obviously enough, we can make no use of the "lines at right angles" approach beyond remarking that the fifth dimension, like the fourth, will have to be "metaphysically at right angles" to the other dimensions, i.e. it will be metric but inexpressible as a vector in terms of any other dimension.

Next we should examine the "intersection" and "join" approaches outlined earlier. Though similar in appearance, these are not different facets of the same process, as it were. If they were simple reversals of one another, we should expect to find some relationship between the interfacial plane produced by the intersection of two solids and the plane surfaces that join to produce at least one of the solids involved, but this does not happen to be the case except in the special circumstance of an intersection that is merely tangential.

Still, ideally both should hold for the fifth dimension, but not necessarily so, for other properties of interdimensional relationships do not hold for all four so far established. For example, a four dimensional object can be represented using only three dimensions as in the case of the 4D chess set. A 3D cube can be represented using only two dimensions by way of a perspective drawing. But a 2D plane cannot be represented using only one dimension.

The join theory is the less helpful of the two; it will be noted that the joining of two lines to make a plane requires that the two lines be separated in the second dimension, therefore the theory already presupposes the existence of the second dimension and also its nature - this could therefore not be predicted by the theory. We cannot "join" two world-lines until we know what separates them.

It is much easier to work the intersection theory in reverse, as was used in the discussion on the nature of the fourth dimension. For a cube, a three-dimensional object to exist, it must satisfy certain requirements. Firstly, it must possess the first three dimensions, i.e. it must have length, depth and breadth. Secondly, it must be suggested by a higher dimension - it must be part of a cube world-line, and it must exist at a particular moment in time. This is a form of the intersection theory. It can also be thought of as the intersection of a four dimensional world-line with a three dimensional universe (the universe at one particular instant), producing a three dimensional object, part of that world-line, just as the intersection of a cube with a plane produces another plane, less than the first plane just as the cube is less than the universe. The strict intersection of two world-lines again produces a three-dimensional object (a cube in the example given), but this is more easily thought of in purely geometrical terms. In simple common sense terms, the intersection of the moment and the world-line can be seen to be quite straightforwardly logical; in order for a cube to be seen at a particular instant, it is necessary that the cube exist immediately prior and immediately subsequent to being seen, and, of course, to be seen at that instant it must exist at that instant.

We must now look at the equivalent one step up the dimensional ladder. The cube world-line must possess length, breadth, depth and duration - are there any other metric properties that it must suggest? It has, most likely, mass, colour, hardness and temperature; do these help us any? On closer examination we find that colour is a form (loosely speaking) of light, and light is a form of energy. Hardness is dependent on arrangement of matter or mass. Temperature is an index of energy. And energy, we understand, is equal to mass times the square of the speed of light. In other words, all our metric properties boil down to mass or energy, which may well be entirely the same thing, especially if it be true that sub-atomic particles are composed of packets of pure energy and no more.

Furthermore, I think it is fair to say that it is a prerequisite of our world-line that it possess mass, and that in order to produce any spatial movement which that world-line might trace out, energy must interact with that mass. Even if the object concerned stays in exactly the same place for the entire duration of its existence, energy is still necessary to bind particles into atoms, atoms into molecules, and molecules into a solid object. The world-line, in as much as it is an object, is the product of mass and energy, and since these two are fundamentally identifiable with one another, I think it is fair to suggest them as a fifth dimension.

Whatever the complexities of the physics implicit in all this, from the geographical point of view it forms a convenient natural philosophy of the geosphere, which can be viewed as a five dimensional manifold, in which pattern and process can be represented by five vectors. These for a flow pattern for example, would constitute: a NS distance component, an EW distance component, an altitudinal component, a temporal component and a quantitative component. These abstractions are inherent in the geographical description of any material phenomena; they answer the questions where? when? and how much? in a well-defined and systematic framework.

This has interesting implications for our concern with perception. Besides perception of space being a function of time, the other suspected source of perceptual distortion mentioned in connection with the philosophy of space was the possibility of space being perceived in terms of the matter contained within that space, discussed in the context of relative space and the philosophy of Descartes. Now were this operational, it could be viewed as another example of dimensional substitution comparable with that discussed in the context of space-time. This time, however, it would be the fifth dimension influencing the perception of the first, rather than the fourth as in the case of time substitution. And if the dimensional scheme suggested can be accepted, then both four and five dimensional influences on distance perception are as natural and understandable as Berkeley's depth being breadth seen from the side.

When we talk of "dimensional substitution" there are two possible ways in which we can regard this, the conventional and the influential. Under the first category we have in mind substitutions of dimension that are in common usage and are conscious implementations of conventions of expression. An example already given is the temporal reply to a question about distance: the remark that "town A is 30 minutes away". Similarly, when an American describes a location as being "three blocks away" he is deliberately using the dimension of matter as a substitute for the dimension of distance. To speak of an office as being on the fifth floor is to give its altitudinal component in the same way. With a little thought one can produce plenty of other examples of this sort of thing, for example, expressing the population of China in terms of the time it would take for them to march past an observation post.

However, we are more concerned here with substitution in terms of influence; the subconscious counterpart to the conventions above. Can we say that attributes of a distance, in terms of its material contents, or the time taken to traverse it, will affect the estimation of that distance? Here we are not looking for the translation of distance into other terms, but the distortion of distance while retaining a spatial form of expression. Whereas the substitutional conventions discussed above do obviously take place, we have little evidence to consider with respect to subconscious influence upon nominally spatial estimations.

To recapitulate then, when considering the nature of cognitive space as shown by cognitive distance, we can consider the following:

(i) To what extent does it exhibit network properties, especially symmetry or commutativity?

(ii) To what extent does its geometry suggest an absolute or a relative space? Is the geometry regular or irregular, and if regular, is it Euclidean?

(iii) Does cognitive distance suggest a curved cognitive space?

(iv) Can a relationship between estimated distance and time or matter be demonstrated?

These and other points will be considered in parts III and IV following.

PART III

THE GLOBAL EXPERIMENT

1) GLOBAL DISTANCE ESTIMATION - A REVIEW OF THE LITERATURE.

(i) Introduction.

Cognitive distance being such a recent addition to the geographer's field of interest, it is not entirely surprising to find that the literature on the subject is fairly limited. Furthermore, what there is is by no means equally divided between the various scales at which the subject can be tackled. The great majority of the published work is concerned with cognitive distance at an intra-urban scale, using relatively short distances from city landmark to city landmark. Very little has been done at an inter-urban or regional scale; three studies will be referred to later but only one of these has actually been published. There is considerably more published work available at the global scale, most of which straddles uncomfortably the gap between geography and psychology. The bulk of this has come from the Psychological Laboratories at Stockholm, with a line of dissonant counterpoint from two psychologists in Australia. Virtually the only study of specifically geographical intent is provided by a small-scale experiment conducted by David Stea.

The consideration of work done at a regional or national scale we shall leave until part IV, together with a brief account of some of the more important material relating to the cognition of urban distance. For the present we can look at the published work dealing with cognitive distance at a global scale, and then consider the problems that this sort of study presents to the experimenter.

(ii) Emotional Involvement.

The various studies that have been carried out at the Psychological Laboratories at Stockholm have been chiefly concerned with studying the relationship between subjective distance and emotional involvement, and in particular, the proving of what Bratfisch terms "the inverse square root law". This hypothesis, first published by Ekman and Bratfisch (1965), states that the emotional involvement of subjects with a particular place varies inversely with the square root of the subjective distance to that place. This derived initially from an experiment in which 46 Stockholm students were presented with lists containing every possible pairing of ten selected cities (Budapest, Copenhagen, Hamburg, Kiruna, London, Montreal, Moscow, Peking, Reykjavik and Vienna); they were "instructed to compare the distance from Stockholm to the two cities of the pair, to indicate which of the two distances was perceived as greater, and to estimate the smaller distance in per cent (sic) of the greater distance." (Ekman & Bratfisch, 1965, p431) The students were then asked to imagine hypothetical events of a dire nature occurring in each city and to use the same method to determine which city of each pair they would feel most involved with. Then, using ratio scaling techniques of a complex nature (Ekman, 1958, Kunnapas, 1960) absolute figures for subjective distance and for emotional involvement were obtained. These figures were then plotted to show that emotional involvement did indeed vary with the inverse square root of subjective distance, except in the cases of London, Moscow and Peking, which had figures showing a much higher emotional involvement than was predicted. This was explained as resulting from the fact that these three cities were more interesting than the other seven.

This was followed up with a second study by Bratfisch in which different groups of subjects (all students) were given different lists of cities (three groups of ten - thirty cities in all - all of them in Europe; Bratfisch, 1969). This time, it was intended that allowance should be made for the fact that larger cities might be seen as especially interesting, as in the case of London, Moscow and Peking cited above. Accordingly, the subjects were all asked to estimate the importance of, their interest in, and their knowledge of, each city in the list. This was to be done by giving each city a point score on an arbitary scale.

At around the same time, Stanislav Dornič (1967) produced a similar experiment under the aegis of Stockholm, but using Bratislava as centre, and Czech students instead of Swedish.

The results of all this were that the values of exponents obtained denoting the relationship between emotional involvement and subjective distance were remarkably constant at about -0.5 . This demonstrated conclusively (at least, to the satisfaction of the Swedes) that emotional involvement varied inversely with the square root of subjective distance, provided either (as Bratfisch would say) that other factors were held constant, or (to quote the Austra lian view of the proceedings) given "a considerable degree of data manipulation to the extent that apparently complex scattergrams were differentiated into up to three curves". (Walmsley, 1974, p. 12)

One of the first problems in considering this topic is to ask whether emotional involvement or subjective distance is to be regarded as the independent variable in this relationship. If one accepted the "law' it would still be valid to ask whether subjects felt more involved with places which they thought were closer, or whether they imagined that places with which they did happen to be involved were closer than they actually were. This point is mentioned in passing by Dornič, and is otherwise not touched upon at all.

The second question is the matter of the relationship between subjective distance and actual distance. For the three experiments constituting Bratfisch's second study he quotes as exponents (i.e. gradients of the regression of log subjective distance on log actual distance) the figures 0.58, 0.90 and 1.08 (Bratfisch, 1969, p 249-50). It is not clear how these figures were obtained, but it seems as though they were taken from a graph on which the data from all the subjects in each group were plotted in one large amalgamation. No regression coefficents are given, but we are told "the scatter around the curves ... is very great. It is due, in part, to the particular complexity of the present problem, which involves ... several subjective partially independent variables." (Bratfisch, 1969, p 251)

The third point worth mentioning is the rather curious discovery by Dornič that "among European cities, all those situated north of the observer's position were generally perceived as closer than e.g. Geneva and Athens ... since most notions of the inter-city distances in our subjects were probably formed on the basis of map inspection, they might well have been influenced by purely perceptual factors including shape, colour and direction on maps". (Dornič, 1967, p 5) However, we note that his figures for the actual distances were obtained from "a large map" - he does not mention whether or not he is aware that large maps are prone to distorting distances, especially in northern regions.

Despite the consistency of involvement/distance exponents in the Swedish studies, when Gordon Stanley (1968) attempted to replicate the Bratfisch "law" using Armidale N.S.W. as centre, and a total of 32 cities scattered about the globe as stimuli, his results were totally inconclusive. Stanley's view of this was that "the inverse square root hypothesis is limited in its application to other cultures and epicentres other than Stockholm". (Stanley, 1968, p 167) However, Stanley's study is not really comparable with the Swedish work. Firstly, while Stockholm used an elaborate ratio scaling technique involving comparisons between many pairs of distances, Stanley asked his subjects to write down estimates of distance as the name of each city was called out (at ten second intervals). Under these somewhat severe conditions, the reliability of such distance estimations as expressions of actual subjective distance is not to be guaranteed. Secondly, all the cities that the Swedes used were more or less in the same hemisphere, and only Montreal and Peking were outside Europe (though Dornic did use Tokyo and Buenos Aires). But with the peripheral position of Australia and the fact that some of the stimulus cities were almost antipodal, Stanley's subjects had a much harder job.

However, the reply made by the Stockholm researchers criticises Stanley for a different reason; the accusation is made (Lundberg, 1970, p 63) that Stanley asked his subjects to estimate actual distance (rather than subjective distance). This, on the surface of it, may seem a little strange; after all, surely estimating actual distance produces subjective distance? It might seem that asking for estimates of subjective distance would produce subjective subjective distance, a very curious stuff indeed. In fact, the matter hinges on the specialised use of the phrase "subjective distance", which was mentioned in part I. The difference between asking subjects to estimate subjective distance and simply asking them to estimate actual distance lies in the fact that the Swedish investigators specifically instructed their subjects to ignore any knowledge they might have (or think they had) as to the actual distances involved, and rely entirely on superficial impression. Stanley can, I think, be forgiven for overlooking the significance of this point, for the phrase "subjective distance" is not clearly explained in any of the various reports, and the above exposition is derived from a letter (unpublished) from Dr Bratfisch to the author.

The point also arises as to the significance of a study in which subjective distance in the Bratfisch sense of the term is used. If a subject does regard himself as well-informed on the matter of actual distance relations, the ability with which he will be able to discard this cognition is a moot point. It seems possible to the author that in order to comply with the experimental demands, a subject might be obliged to draw upon such things as emotional involvement to fabricate answers that are sufficently "subjective". Were this to happen, the experimental results would be trivial; on the other hand, it is easy to see that if level of information is a major contributory factor to cognitive distance, this is unlikely to have any psychological variations with respect to emotional involvement. The position can be viewed as a methodological dilemma, with the Swedes on one horn and Stanley on the other (but see section 5).

Nothing daunted, Stanley came back with another study (Stanley, 1971) now centred on Melbourne instead of Armidale. This time he took Lundberg at his word and split his subjects into two groups, one of which was asked to estimate physical distance as before, but the other was (according to the report) asked to estimate subjective distance. It is not clear whether this instruction meant the same thing to Stanley and his students as it did to Bratfisch and Lundberg.

According to the Bratfisch hypothesis, the expected exponent of emotional involvement and subjective distance should be -0.50; Stanley got a range of values, but none of them exceeded -0.456 and the median was -0.231 . The subjects who were asked to estimate subjective distance did get consistently larger exponents than those who estimated physical distance, if that is to be counted any comfort.

Stockholm produced their reply to this in a paper by Lundberg and Ekman (1970), now suggesting that the location of Australia "may have caused a different spacing of the stimuli" and also that "minor differences in instructions and experimental conditions" could be responsible for the variation in exponents. Bratfisch and Lundberg then summed up their work as sufficently demonstrating the inverse square root "law"(Bratfisch and Lundberg, 1971).

Back in Armidale, Walmsley found this a case of "incongruent findings ... dismissed all too easily on rather trivial methodological grounds" (Walmsley, 1974, p 12); he also suggested that the Swedish studies showed a range of distances that was "strangely limited". He then conducted experiments to attempt to reproduce the square root phenomenon in Australia, this time following Lundberg virtually to the letter to allow no room for equivocation. The result: as before, a range of exponents which Walmsley suggests is a function of the range of stimuli presented. There the matter rests at present.

What can the geographer draw from all this? Not, in fact, a great deal. With all the argument as to whether any relationship exists at all, there has been virtually no theoretical consideration of what processes may or may not be at work. If emotional involvement is dependent upon subjective distance, this is not something that the geographer can contribute to or take an interest in. But if the relationship is the other way round, and places that are identified with strongly appear to be relatively closer than neutral or even emotively hostile places (for instance, the comparison between the distance from Dublin to Cork and the distance from Dublin to Belfast mentioned in the introduction), this will be of some concern to any geographer wishing to deal with the topic of cognitive distance.

Aside from that, one of the few conclusions is that the observed relationship between cognitive distance and actual geographical distance would appear to be logarithmic, with a wide range of exponents.

One other point worth mentioning is a remark by Walmsley, who hints that no consideration has been given to the question of whether the subjects who were given the task of estimating distances felt that they had given valid approximations relating to genuine feelings about the distances, or whether they were, in fact, forced to guess randomly. This matter of uncertainty in estimations (related, perhaps, to geographical awareness) might have a significant bearing on the validity of any results obtained from this sort of study.

(iii) Sphere and Plane

A different experiment carried out by Lundberg (1973) was designed to determine, by measurements of subjective distance, whether the world is perceived in planar or in spherical terms. His experimental procedure was as follows: having selected thirteen places around the globe, he asked 60 students for estimates of all the possible subjective interdistances, and then processed these using a multi-dimensional scaling technique to obtain the result that the estimations could be contained on a Euclidean plane with 10% stress ("stress" being a measure of preciseness of fit - the lower the better). This constituted a "fair" result in Kruskal's terms.

This particular experiment is also a departure from previous practice in that, instead of asking subjects the distance from the subject's location (i.e. in this case, Stockholm) to a remote place, subjects were asked to estimate distances between two remote places. This may be dangerous. If we consider man to be basically anthropocentric, while it may be all right to ask him to estimate distances from "here", to ask him to estimate distances from some remote place may be to force a shift of perspective which will have a deleterious effect on the quality of the estimates obtained, particularly in the degree of confidence the subject is likely to express in his estimations. It seems not unreasonable to hypothesise that a subject may be less aware of distant places than of close ones in such a way that certain elements of the cognitive positions of the former may be very much more shadowy than others. For example, the subject may be aware that Tokyo is far away, and Sydney further still, and even have reasonable confidence in estimating how much further still, but this is in terms of distances away from him. Estimating how much further Sydney is from Stockholm than Tokyo is and estimating distance from Sydney to Tokyo or vice versa are two different things and require different sorts of knowledge. To estimate the distance of Sydney from Tokyo it is necessary for the subject to make a cognitive shift, to put himself in the place of Tokyo and to relate to other places from there. The distances from Tokyo to other places are much less cognitively relevant than the distances of those places from the subject, and his skill at estimating those distances may well be correspondingly less.

Another thing that may colour estimations made between two places that are both remote from the subject is the extent to which one or other of the two places is distant from him. As an illustration of this, it may be that Stockholm students faced with the task of estimating distances from London would have found it an easier job than estimating distances from Calcutta, since the cognitive shift of perspective required is not so great. They would therefore be able to give better estimates; better in the sense that the estimates would be expressed with more confidence, and less resembling random number generation. On the other hand, it may have been that the subject's estimates of the distances from London were unduly influenced by their ideas of the distances from Stockholm - a sort of cognitive inertia in which a limited shift in perspective is not sufficently violent to clear away the tendency to relate to one's own position in space. Until this particular topic has been investigated more thoroughly, the estimation of remote interdistances must be viewed with some caution.

Mention must also be made of the way in which Lundberg asked his subjects to estimate the distances involved: as a proportion of the distance between the North Pole and the South Pole. One can sympathise with the choice of this as standard, it being a convenient (that is, convenient from the experimenter's point of view) way of expressing half the great circle circumference of the earth, the maximum possible distance from any place to any other place on the surface of the globe. However, from the subject's point of view it is more ambiguous. A subject not educated in the use of globes might well be hazy about the properties of great circles and antipodes; might even not realise that no distance can be greater than the standard given. The distance from the North Pole to the South Pole could be viewed as the distance between the poles on a map of unspecified projection, or as the distance between then on a flat photograph of a globe, in which the earth appears as a circle rather than as a sphere. One would expect no necessary consistency among the subjects either in interpretation or in skill in manipulating this slightly unwieldy measuring stick. Nor is it necessary that a subject would be consistent within his estimates (that a map-based standard would automatically lead to planar results to the experiment), for while trans-polar distances might be recognised as such and estimated accordingly, a distance along the Greenwich Meridian might invite planar thinking. As will be seen later, there is some evidence to support this view.

Another possibility is that a subject finding the circumferential standard hard to visualise all at once might be unconsciously steered into thinking in easier, Euclidean terms, whereas if the measuring stick were smaller and therefore both easier to visualise and more consistent from globe to map, it would be easier for a subject to build up an image of the distances in spherical terms. Half the trouble is, perhaps, that one is scraping the surface of a very complicated, virtually untouched, and even as yet ill-defined, problem.

(iv) Barriers.

The one remaining study to be discussed is the contribution of David Stea who conducted an experiment at Clark University and again at Seattle, using 22 and 37 students respectively as subjects (Stea, 1969a). Each group estimated distances and air travel time to eleven other cities, though in the case of the Clark University students, half were asked the distance from New York to the other cities involved, while the other half were asked to estimate the distances from the other cities to New York. (The latter group gave lower, but not significantly lower, estimates.) Although the results have not been published in full, they showed that distances objectively greater than 4,000 miles tended to be underestimated while distances less than that tended to be overestimated; this is consistent with a logarithmic relationship between cognitive and geographical distance (though this is not mentioned as such).

What is more important is that Stea develops for the first time the idea of barriers affecting the perception of distance at a geographical scale; this is consonant with the hypothesis of distance being perceived in terms of things, or, at least, obstacles, contained therein. In this experiment he examined three sorts of barriers, categorised as marine, political and linguistic divides. The results did not appear to differentiate between these different types, but there was a suggestion that they were responsible for overestimation. However, since the longer a distance is, the more barriers it is likely to contain, this trend runs directly counter to the previous one mentioned in which underestimation rather than overestimation increased with distance. As will be seen later, careful structuring of experimental methodology can isolate these two different trends and remove the confusion.

This comprises the total of the published literature on the cognition of global distance to date. It will next be appropriate to consider in detail the problems which a study of this sort presents to the experimenter.

2) THE PROBLEMS OF EXPERIMENTAL DESIGN

(i) Which Distance?

One of the great problems with regard to cognitive studies in general, and studies of cognitive distance in particular, is that very rarely is there any "right" answer. It is no simple thing to say that "the distance from A to B is such-and-such"; when working at a global level, though one can measure the great circle distance and call it correct, it is also possible to measure the same distance on a map, and call this distance, in its own way, correct, or at least, objective. And, of course, map distances vary from projection to projection. It is also possible to posit an experiential "travel distance" consisting of the space actually traversed by boat, railway, aeroplane or whatever, but since intercontinental travel is not an everyday activity for most people, this is less important at this particular scale.

This problem arises in two different ways. Firstly, the experimenter will have to decide which sort of distance he will ask his subjects to estimate - with the option of leaving it blank and merely asking for distance unspecified. Great circle distances have a certain advantage in that they are relatively unique, whereas map and travel distances suffer from variation in projection and route. However, to ask specifically for great circle estimations might be regarded as "giving the game away" with respect to a subject who might have been more naturally inclined towards thinking in terms of a map; it could be seen as constraining the subject's freedom of expression slightly. Whereas Stea did ask specifically for great circle distances, the other experimenters mentioned seem to have left the matter up to the subject.

The second consideration here is, having obtained distance estimations, should one compare them to sets derived from the globe or from a map, and, if the latter, which map? Stea, since he asked for great circle distances, naturally uses great circle distances as the basis for comparison. Bratfisch mentions that he obtained figures for actual great circle distances from the airline SAS (Bratfisch, 1965); it is only Dornič, who, as mentioned before, used map distances (projection unspecified) as a standard.

(ii) Estimation Technique

There are various different ways of asking people to estimate distances, and these have various advantages and disadvantages. The first and most obvious is to ask for estimates in straight mileages (or kilometres if preferred). This has the advantage of simplicity, but also a number of disadvantages, particularly at this scale. Whereas most people are reasonably familiar with what a mile looks like stretched out flat, visualising a thousand miles is a much harder task. The author can acutely recollect an occasion, some years ago, when, needing to estimate the distance to Australia in miles, he found himself quite unable to decide even on the approximate scale, whether in thousands or tens of thousands of miles. On the other hand there is also the danger of misremembered figures interfering with the process of pure estimation. A subject might be plagued by a nagging suspicion that a particular distance was "either 3,000 or 5,000" or somesuch. There is nothing "natural" about miles as a measure of distance; a subject may may have a good idea of the length of a particular distance in purely spatial terms (he can visualise it easily on a globe or map) and yet have no basis on which to translate this cognition into miles.

The alternatives are to use either multi-ratio scaling or single ratio scaling. The former technique (used by Bratfisch and Ekman) is based on comparisons made in relative terms of pairs of distances in every possible arrangement. These relative comparisons are turned by mathematical manipulation into absolute numbers. While this method avoids the problem of having to choose a single standard against which estimations are to be made, it has the disadvantage of being cumbersome in the extreme. The subject is called upon to make a very large number of estimations.

Single ratio scaling involves nominating an initial distance to be used as a standard. Estimates then have to be expressed in terms of the ratio of the stimulus distance to the standard. Actually, there is a similarity between this technique and that of simple mileage estimation, since "one mile" is a standard distance. The difference lies in the fact that a mile is a general term; it would be different were one to ask for estimates with respect to "the distance AB" where this standard distance AB was in fact one mile.

Estimates can be given either as numbers, or by marking off proportional lengths on a line. The graphical method has the advantage of providing a visual counterpart to the actual distances, and also of tending less to yield estimates concentrated on round numbers. Its disadvantage is that the length of the lines presented to the subject on which the estimates are to be marked may affect his judgement if he feels that all the space has got to be used - that the longest distance will necessarily occupy the maximum amount of line; or, of course, the lines may be too short for him. With numerical estimates there is no apparent upper limit, and therefore less sense of an implied scale of estimation.

There remains the problem of selecting the standard distance to be used. This can be small, so that estimates must be expressed as multiples, or large, so that estimates must be expressed as fractions, or medial. But what is important is that the standard selected should be familiar and easily cognisable itself; preferably something that will be perceived consistently by all the subjects.

In the studies mentioned above, mileage estimation was used by Stanley and Stea (this is implicitly suggested in the reports, but not explicitly stated), multidimensional scaling was used by Bratfisch, Ekman and Dornic, and (presumably) Walmsley, while Lundberg used single ratio scaling with a large standard distance.

(iii) Scale Problems

One of the drawbacks to this sort of study is that the results obtained from a distance estimation experiment perforce express two different things - firstly, how subjects estimate distance, and secondly, how they estimate anything at all. As was discussed in part I, cognition and estimation are different skills entirely, and, given a hypothetical consistency of perception in a group of subjects, variation in estimation skills could produce a wide variety of experimental results.

Consider the hypothetical case of a subject involved in an experiment on cognised length, in which he has been shown two lines, one of which is one inch long, the other twelve inches. Let us suppose that these have both been accurately perceived, and that the subject is capable of envisaging both lines with perfect precision. If the subject is now asked to express the ratio of the two lengths, he will have to call into play mental skills of comparison and estimation, and (since we have assumed perfect perception) deficiencies in these will be responsible for any discrepancies in the experimental results.

Two effects are possible. Firstly, the scale of estimation may vary from subject to subject. A subject who calculated, in our inch and foot example, that the longer line was ten times the length of the shorter, might be expected to estimate a two foot length as twenty times as long, and so on. Another subject, though, might have fitted the shorter line into the longer fifteen times, and would correspondingly give an answer of thirty for the two foot length. This is not to say that the two subjects perceive the lengths any differently from one another; they merely tend to estimate things at different scales. Thus if it is experimentally determined that when subjective distance is plotted against actual distance for each subject, a wide range of exponents is obtained, this is not necessarily related to how the subjects cognise the distances, but could be entirely produced by the matter of how they estimate their cognitions. If the experimenter is concerned with true cognitions, he is going to have to devise some way round this problem. The constantly shifting standard in the multi-ratio scaling technique is one way round; the author's own solution will be discussed at length later.

The second effect is similar. We know very little about how perceptions are evaluated numerically in the estimation process, and we cannot assume that estimated distance is derived from perceived distance in a linear relationship; it may bear a logarithmic relationship. Therefore, if cognitive distance appears to be logarithmically related to actual distance, this may be due to the processes of estimation rather than those of perception. For example, the ratios 2:1 and 3:1 can be distinguished from one another with a relative degree of ease; the ratios 9:1 and 10:1 are more blurred, and it would take some acuity to distinguish between 32:1 and 33:1. Therefore one can understand a tendency to round down higher ratios more than lower ones, and this would produce a generally curvilinear pattern of estimation. If this were to be the case, one should observe the same logarithmic pattern in a mock distance estimation experiment where the subjects could observe the distances on a wall map in front of them. This has not been tested experimentally; The psychological aspect of the above is discussed in section 5.

It will be recalled that in Stea's experiment it was found that the vaguely logarithmic trend to the data appeared to mask the effect of possible cognitive barriers. If this logarithmicity is purely a product of the estimation process, rather than being a component of true cognition, then it would seem to be advantageous to eliminate the logarithmic trend to the data if at all possible, in order to remove the undesirable "noise".

(iv) Subjects

It may be worth mentioning the question of choice of subjects; all the experiments previously discussed used university students as subjects, and occasionally one hears this criticised as a weakness. The complaint seems to be that such a specialised and restricted group could be expected to yield different results from those of "ordinary people".

Apart from the fact that this argument probably overestimates the homogeneity of the student community, and underestimates the extent to which students, too, are "ordinary people", there are various defences of the use of students as subjects. Firstly, there is the pragmatic approach: the experiments involved with this sort of study tend to be both tedious and difficult to complete, especially when more elaborate techniques like multi-ratio scaling are used. Without a captive (or paid) audience, one might be very unlikely to get any results at all. Secondly, one must allow that a cognitive experiment must be relevant to those who participate in it. One can ask a Scot to estimate distances around Scotland, but to ask a native of Bratislava the same questions would be fruitless. Similarly, there is no point in asking questions about global distances unless the respondents involved actually have valid cognitions of the places involved. Students are one group whom one might reasonably expect to be familiar with the places involved in a global study. To quote Dornič:

"There is probably a necessary lower limit of intelligence or general education below which subjects can hardly participate in this type of scaling experiments (sic)." (Dornič, 1967, p. 2)

3) THE DESIGN OF THE EXPERIMENT

(i) Absolute Scales

Since there is no real evidence to show whether global cognition is primarily map-oriented or is actually derived from the world envisaged as a sphere, it would seem unwise not to test for both. Consequently two lists of distances were prepared as absolute distances to which the subject's estimates could be compared. The first of these consisted of great circle distances calculated trigonometrically from the latitude and longitude figures in an atlas (Philip,1969). The second list was of the same distances measured on a large wall map of the world on Mercator's projection, in millimetres. These two lists were then standardised by dividing through by the distance from Edinburgh to London, so that this distance had a value of one unit, and all the others were multiples of it.

The choice of Mercator's projection rather than any other was not to show that distance cognitions were related exactly to that particular projection, but rather as a test case for general "map-like tendencies". Also, Mercator's projection is, in some ways, the archetype of all world maps; it is difficult to think of one other projection that is as well-known. Similarly, one can think of the great circle distances as being a test for "globe-like tendencies" rather than an exclusive model. There is no reason why a subject should not be inconsistent and relate some distances to globe and some to map.

(ii) Estimation Technique

For reasons already discussed, it was felt that the procedure of asking for estimates in miles was, at this scale of operations, fraught with too many problems to be considered seriously. The complexity of the multi-ratio scaling technique ruled it out of court for an experiment as large as that intended, so a single ratio scaling technique was decided upon, in which subjects would compare the distances to be estimated (the stimuli) to one standard distance.

In choosing the standard, the first problem was that of deciding the length. Lundberg used the maximum possible distance; it has also been suggested (source not discoverable) that a medial standard is preferable, since reaction to differences is less standard at the extreme ends of the magnitude scale. It is the author's personal prejudice that in general it is easier to visualise multiples than fractions, and that building up from a small standard is easier than breaking down a large one. (See also sub-section (v) below.) But as well as this, it was desirable that the chosen standard should be (a) as familiar as possible (b) as free from barriers, especially marine barriers, as possible. This rather dictated a short distance, and since it was intended that all the distances involved should be from Edinburgh (since, as has already been discussed, estimates of remote interdistances may be less reliable than, or intrinsically different from, estimations of distances from the subjects' actual location), the choice of Edinburgh to London was rapidly settled upon.

The other thing to be decided was whether to obtain estimates numerically or graphically. A short pilot test of both methods showed that the numerical technique was easier to handle and apparently preferable to the subjects, and so the graphical technique was abandoned.

(iii) Choice of places

Apart from Edinburgh and London, 24 other places were selected for the questionnaire. Several considerations were important in choosing the places involved. Firstly, it was desired that as good a spread as possible over the whole globe should be obtained - this dictated the relatively large number of places chosen. Secondly, it was essential that all the places should be reasonably well-known. (Obviously no-one can estimate the distance to a place the location of which they are ignorant.) In the pilot test it was found that two subjects confused Hawaii with Haiti, and Vladivostok caused some trouble as well. The selection was tidied up for the main experiment, though even then, one subject confused Lagos with Laos (and was therefore dropped).

The final list was as follows (in increasing great circle distance from Edinburgh): Dublin, Paris, Oslo, Reykjavik, Warsaw, Madrid, North Cape (Norway), Algiers, Moscow, Athens, North Pole, Jerusalem, New York, Lagos, Bering Straits, Peking, Calcutta, San Francisco, Saigon, Cape Town, Honolulu, Buenos Aires, South Pole and Christchurch.

There were various reasons for selecting the places individually; some were merely obvious representatives of the general area (for example, Buenos Aires - Rio de Janiero would have done just as well). Others were picked in almost equidistant pairs, as in the case of Warsaw and Madrid, to see how far separated these became in the actual estimates. Oslo is the nearest non-British city across (mostly) sea, whereas Paris is the nearest across (mostly) land. Algiers is the nearest city in another continent; the position of the two poles is ambiguous on many maps, including the Mercator projection; Bering Straits is a good example of a trans-polar distance, and Christchurch is the nearest city to the Antipodes, thus giving a convenient maximum distance.

(iv) Subjects

Four groups of subjects were used: (numbers following are sample size in terms of number of subjects returning complete sets of answers) Edinburgh University third year geography students (21); ditto second year students (44); St Andrew's University first year geography students (60); Queen's University Belfast third year geography students (57).

With regard to the second two groups, the St Andrew's students completed the same questionnaire as was given to the Edinburgh students. At this scale it was felt that the small distance between Edinburgh and St Andrew's would not make any difference; in any case, if a significant difference in results were discovered it could be noted as such.

The Belfast students were given a slightly different experiment, estimating distances from Belfast rather than from Edinburgh, using the distance from Belfast to Dublin as standard. It was decided to use the two endpoints of the Scottish standard distance, Edinburgh and London, as stimuli in this experiment. Dublin obviously could not be used as a stimulus since it was part of the new standard, and to keep the total number of stimuli the same for all sample groups, Bering Straits was dropped for the Belfast group.

(v) Procedure

Each subject was presented with a questionnaire on which appeared the 24 places in a random order. The order in which the places appeared was different for every questionnaire. The first task the subject was given was to re-arrange the places in order of increasing distance from Edinburgh. This was intended to focus his attention on the relative distances, and to make quite sure that he would not give hurried estimates in which distance X might be given as longer than distance Y, whereas, were he forced to make that specific comparison in isolation, he would realise clearly that Y was actually longer than X. In some previous experiments of global distance estimation, subjects have been asked to give quick, impressionistic estimates. This, the author feels, does cognition little justice. The implication is that if the subject thought hard about the answer he would get it right, and that not allowing this is the only way to approach the subject "cognitively". But if the subject is capable of giving an accurate answer given due consideration, this means that his cognition is accurate, and not allowing him to express it by restricting his time is to study snap estimation rather than cognition.

The second year students at Edinburgh were not asked to perform this re-arrangement, to see what difference it would make. However, they were still not limited in the amount of time they had for the consideration of each estimate.

The re-arrangement complete, subjects were asked to estimate the distance to each place as a ratio of the distance from Edinburgh to London. Instead of specifically asking for great circle distances, the phrase "shortest distance" was used, which implies great circle distance but allows the subject some latitude. The advantage of using a small standard, combined with the re-arrangement technique will now be apparent. As each increasing estimation had to be made (X_1, X_2, ... X_n) the subject had the opportunity of asking himself "how much further is X_n than X_{n-1} (or X_{n-2} or whatever)?" The subject is enabled to use previous estimations as standards for further ones, thus combining some of the advantages of multi- and single ratio scaling in one technique.

Next, each subject was asked to express his confidence in each of his estimations by assigning it a number from one to ten, given the scale of 10 = very certain this is accurate, down to 1 = just a guess. This was intended to see if results that might have been attributed to miscognition could be explained in terms of self-admitted ignorance.

The subjects were also asked to put down the actual mileages to any of the places if they really did know it, with instructions not to estimate, but only to give figures they remembered and knew to be accurate. The intention behind this was to check on whether estimates were being based on the remembering, or misremembering, of mileage figures. Very few answers to this section were obtained - most of those that were referred to New York and occasionally San Francisco; some were quite inaccurate, but most were reasonable. These answers were not processed further. Similarly, the actual (shortest) distance to London, if known, was requested: the figures obtained were mostly of the order of 400 miles, which is in fact the road distance and represents an overestimation of the great circle distance, but, as will be seen, this does not make any difference.

Subjects were asked to indicate any places they had actually visited, to check on whether this had any effects on their estimates, but the number so indicated were too few to be processed.

Apart from the differences in places and standard mentioned above, the Belfast experiment was conducted in the same way as the Edinburgh/St Andrews experiments were.

4) ANALYSIS

(i) SPSS Frequency Analysis

From each subject's questionnaire, three columns of data were taken - values for the estimated rank order of each place, the estimated distance to each place, and the confidence expressed in each distance estimate. The rank values were taken from the re-arranged order, except in the case of the Edinburgh second year students, where it was derived from the distance estimates - thus allowing paired rankings. The distance estimates were all expressed in standard figures (Edinburgh to London or Belfast to Dublin); the confidence estimates were all integers from one to ten.

These data were then fed to an SPSS Frequencies programme, which calculated for each place descriptive statistics for the total data submitted. The three Edinburgh groups (i.e. including St Andrews) were dealt with as separate populations at first, and then combined into one large population. Since the Frequencies programme is able to handle missing values, unlike the other programmes that were used, some of the subjects who had not totally completed the questionnaire were able to be included. The final numbers for each population were: Edinburgh third year (referred to henceforward as E3) 22, Edinburgh second year (E2) 44, St Andrews first year (SA) 65, these three combined (AL) 131, Belfast third year (B3) 67. (The numbers were at one stage E3:23 and E2:45, but two subjects were dropped for reasons mentioned below.)

The most interesting results of this analysis are presented as tables 3.1 - 3.5. In table 3.1(a), the first two columns show the the rank of each place ordered by increasing distance from Edinburgh using distances measured on the globe and on a Mercator projection map respectively. The remaining show the means of the estimated

Table 3.1(a)

MEAN RANK ESTIMATES

Place	Gt.C.Rank	Map Rank	E3	E2	SA
Dublin	1	1	1.30	1.11	1.34
Paris	2	2	2.83	2.78	2.91
Oslo	3	3	2.39	2.71	2.27
Reykjavik	4	5	6.17	4.71	6.41
Warsaw	5	6	6.44	6.89	7.55
Madrid	6	4	5.22	5.20	5.69
N.Cape	7	10	7.35	5.80	5.64
Algiers	8	7	9.00	8.11	9.30
Moscow	9	9	9.30	10.16	9.72
Athens	10	8	8.04	8.04	8.48
N.Pole	11	14	12.22	10.62	11.64
Jerusalem	12	11	10.91	10.96	11.58
New York	13	13	12.96	12.27	13.22
Lagos	14	12	14.13	13.11	14.11
Bering Sts.	15	22	15.57	16.58	16.05
Peking	16	15	20.57	20.24	20.09
Calcutta	17	19	15.70	16.18	16.20
San Francisco	18	18	17.83	17.24	17.36
Saigon	19	20	18.74	18.84	19.06
Cape Town	20	16	17.96	16.29	17.41
Honolulu	21	21	20.44	20.20	20.03
Buenos Aires	22	17	18.22	16.58	17.83
S.Pole	23	23	23.05	21.89	22.65
Christchurch	24	24	23.44	22.96	22.97

E3 = Edinburgh 3rd year students
E2 = Edinburgh 2nd year students
SA = St.Andrew's 1st year students

Table 3.1(b)

RECONSTRUCTED RANK ORDERS

Gt.Circle	Map	E3	E2	SA
Dublin	Dublin	Dublin	Dublin	Dublin
Paris	Paris	Oslo	Oslo	Oslo
Oslo	Oslo	Paris	Paris	Paris
Reykjavik	Madrid	Madrid	Reykjavik	N.Cape
Warsaw	Reykjavik	Reykjavik	Madrid	Madrid
Madrid	Warsaw	Warsaw	N.Cape	Reykjavik
N.Cape	Algiers	N.Cape	Warsaw	Warsaw
Algiers	Athens	Athens	Athens	Athens
Moscow	Moscow	Algiers	Algiers	Algiers
Athens	N.Cape	Moscow	Moscow	Moscow
N.Pole	Jerusalem	Jerusalem	N.Pole	Jerusalem
Jerusalem	Lagos	N.Pole	Jerusalem	N.Pole
New York	New York	New York	New York	New York
Lagos	N.Pole	Lagos	Lagos	Lagos
Bering Sts.	Peking	Bering Sts.	Calcutta	Bering Sts.
Peking	Cape Town	Calcutta	Cape Town	Calcutta
Calcutta	Buenos Aires	San Francisco	Bering Sts.	San Francisco
San Francisco	San Francisco	Cape Town	Buenos Aires	Cape Town
Saigon	Calcutta	Buenos Aires	San Francisco	Buenos Aires
Cape Town	Saigon	Saigon	Saigon	Saigon
Honolulu	Honolulu	Honolulu	Honolulu	Honolulu
Buenos Aires	Bering Sts.	Peking	Peking	Peking
S.Pole	S.Pole	S.Pole	S.Pole	S.Pole
Christchurch	Christchurch	Christchurch	Christchurch	Christchurch

Table 3.2

MEDIAN DISTANCE ESTIMATES

Place	Gt.C. Distance	Map Distance	E3	E2	SA
Dublin	.66	.68	.74	.77	.83
Paris	1.63	1.60	1.48	1.57	1.51
Oslo	1.74	1.92	1.46	1.51	1.45
Reykjavik	2.57	3.00	2.97	2.48	3.03
Warsaw	3.03	3.24	2.53	3.02	3.55
Madrid	3.23	2.84	2.56	2.89	3.02
N.Cape	4.06	5.48	3.25	3.02	2.97
Algiers	4.09	3.48	4.13	4.02	4.78
Moscow	4.68	4.80	4.56	5.04	5.01
Athens	5.28	4.56	3.75	4.07	4.98
N.Pole	7.07	10.48	5.88	5.94	6.45
Jerusalem	7.46	6.20	5.06	5.58	6.02
New York	9.79	9.00	6.47	7.50	7.63
Lagos	10.34	7.52	7.83	7.75	8.48
Bering Sts.	11.97	20.12	9.94	13.17	10.53
Peking	14.83	12.28	14.83	16.83	16.07
Calcutta	15.01	14.72	8.94	11.90	12.00
San Francisco	15.21	14.72	12.00	12.20	12.10
Saigon	19.03	14.92	14.92	14.90	15.96
Cape Town	19.05	12.84	11.09	11.13	14.06
Honolulu	20.72	19.52	14.75	16.88	17.00
Buenos Aires	21.15	14.32	12.00	11.88	13.63
S.Pole	30.30	20.72	17.83	19.67	23.25
Christchurch	34.45	25.40	18.00	22.00	23.94

Table 3.3

MEAN CONFIDENCE ESTIMATES

	E3	E2	SA
Dublin	6.44	6.18	6.80
Paris	6.35	6.38	6.72
Oslo	6.04	5.40	6.22
Reykjavik	4.70	4.71	4.58
Warsaw	4.09	3.67	4.34
Madrid	4.96	5.16	5.44
N.Cape	3.91	3.69	4.19
Algiers	4.27	4.13	4.19
Moscow	3.96	4.33	4.14
Athens	4.17	3.96	4.76
N.Pole	3.22	3.36	3.63
Jerusalem	3.65	3.58	3.95
New York	4.65	5.11	5.06
Lagos	3.39	3.11	3.06
Bering Sts.	2.65	2.60	3.03
Peking	2.22	2.27	3.03
Calcutta	2.78	2.58	3.33
San Francisco	3.91	4.02	4.25
Saigon	3.00	2.24	2.81
Cape Town	3.04	2.91	3.64
Honolulu	2.70	2.42	2.84
Buenos Aires	2.83	3.04	3.25
S.Pole	3.05	2.33	2.83
Christchurch	2.52	3.09	3.52

Table 3.4(a)

BELFAST RESULTS

Place	Gt.C. Rank	Map Rank	Mean Estimated Rank
Edinburgh	1	1	1.03
London	2	2	1.99
Paris	3	3	3.19
Oslo	4	4	4.55
Reykjavik	5	6	7.08
Madrid	6	5	5.81
Warsaw	7	8	8.09
Algiers	8	7	9.96
N.Cape	9	11	8.62
Moscow	10	10	11.73
Athens	11	9	9.36
N.Pole	12	15	13.80
Jerusalem	13	12	12.24
New York	14	14	14.02
Lagos	15	13	15.13
San Francisco	16	19	17.70
Peking	17	20	19.65
Calcutta	18	16	17.02
Cape Town	19	17	16.72
Saigon	20	21	19.49
Buenos Aires	21	18	17.15
Honolulu	22	22	20.39
S.Pole	23	23	22.21
Christchurch	24	24	22.02

Gt.C Order	Map Order	Estimated Order
Edinburgh	Edinburgh	Edinburgh
London	London	London
Paris	Paris	Paris
Oslo	Oslo	Oslo
Reykjavik	Madrid	Madrid
Madrid	Reykjavik	Reykjavik
Warsaw	Algiers	Warsaw
Algiers	Warsaw	N.Cape
N.Cape	Athens	Athens
Moscow	Moscow	Algiers
Athens	N.Cape	Moscow
N.Pole	Lagos	Jerusalem
Jerusalem	N.Pole	N.Pole
New York	New York	New York
Lagos	Jerusalem	Lagos
San Francisco	Cape Town	Cape Town
Peking	Saigon	Calcutta
Calcutta	San Francisco	Buenos Aires
Cape Town	Peking	San Francisco
Saigon	Buenos Aires	Saigon
Buenos Aires	Calcutta	Peking
Honolulu	Honolulu	Honolulu
S.Pole	S.Pole	Christchurch
Christchurch	Christchurch	S.Pole

Table 3.4(b)

BELFAST RESULTS

	Actual Gt.C. Distance	Actual Map Distance	Median Distance Estimate	Mean Confidence Estimate
Edinburgh	1.63	1.38	1.58	7.88
London	3.47	2.88	2.88	7.82
Paris	6.06	4.75	4.63	6.82
Oslo	8.26	7.25	5.94	5.48
Reykjavik	9.83	9.25	7.10	4.59
Madrid	11.22	8.13	7.45	5.34
Warsaw	12.71	10.88	9.17	3.89
Algiers	14.92	10.38	10.92	4.06
N.Cape	16.95	18.25	9.04	3.66
Moscow	19.28	16.00	12.90	3.54
Athens	20.54	14.50	11.00	3.99
N.Pole	27.91	33.38	18.25	3.28
Jerusalem	29.02	19.50	16.00	3.22
New York	36.17	26.75	25.13	5.48
Lagos	38.42	22.75	23.25	2.74
San Francisco	57.56	44.68	40.22	4.69
Peking	57.90	46.68	50.25	2.39
Calcutta	58.29	38.88	30.21	2.69
Cape Town	71.89	39.50	32.13	3.02
Saigon	73.79	47.25	45.00	2.38
Buenos Aires	78.64	43.25	35.13	2.94
Honolulu	79.10	59.25	55.13	2.59
S.Pole	113.93	63.75	60.25	2.77
Christchurch	130.85	79.13	63.00	3.37

Table 3.5(a)

COMBINED EDINBURGH RESULTS

Place	Gt.C. Rank	Map Rank	Mean Estimated Rank
Dublin	01	01	01.25
Paris	02	02	02.85
Oslo	03	03	02.44
Reykjavik	04	05	05.75
Warsaw	05	06	07.12
Madrid	06	04	05.47
N.Cape	07	10	05.99
Algiers	08	07	08.87
Moscow	09	09	09.79
Athens	10	08	08.30
N.Pole	11	14	11.36
Jerusalem	12	11	11.29
New York	13	13	12.84
Lagos	14	12	13.73
Bering Sts.	15	22	16.16
Peking	16	15	20.27
Calcutta	17	19	16.13
San Francisco	18	18	17.39
Saigon	19	20	18.92
Cape Town	20	16	17.15
Honolulu	21	21	20.24
Buenos Aires	22	17	17.45
S.Pole	23	23	22.44
Christchurch	24	24	23.05

Gt.C. Order	Map Order	Estimated Order
Dublin	Dublin	Dublin
Paris	Paris	Oslo
Oslo	Oslo	Paris
Reykjavik	Madrid	Madrid
Warsaw	Reykjavik	Reykjavik
Madrid	Warsaw	N.Cape
N.Cape	Algiers	Warsaw
Algiers	Athens	Athens
Moscow	Moscow	Algiers
Athens	N.Cape	Moscow
N.Pole	Jerusalem	Jerusalem
Jerusalem	Lagos	N.Pole
New York	New York	New York
Lagos	N.Pole	Lagos
Bering Sts.	Peking	Calcutta
Peking	Cape Town	Bering Sts.
Calcutta	Buenos Aires	Cape Town
San Francisco	San Francisco	San Francisco
Saigon	Calcutta	Buenos Aires
Cape Town	Saigon	Saigon
Honolulu	Honolulu	Honolulu
Buenos Aires	Bering Sts.	Peking
S.Pole	S.Pole	S.Pole
Christchurch	Christchurch	Christchurch

Table 3.5(b)

COMBINED EDINBURGH RESULTS

	Actual Gt.C. Distance	Actual Map Distance	Median Distance Estimate	Mean Confidence Estimate
Dublin	.66	.68	.77	6.50
Paris	1.63	1.60	1.50	6.50
Oslo	1.74	1.92	1.48	5.93
Reykjavik	2.57	3.00	2.99	4.70
Warsaw	3.03	3.24	3.03	4.09
Madrid	3.23	2.84	2.99	5.26
N.Cape	4.06	5.48	3.00	4.01
Algiers	4.09	3.48	4.48	4.19
Moscow	4.68	4.80	5.00	4.22
Athens	5.28	4.56	4.05	4.38
N.Pole	7.07	10.48	6.01	3.49
Jerusalem	7.46	6.20	5.96	3.79
New York	9.79	9.00	7.48	5.07
Lagos	10.34	7.52	7.98	3.15
Bering Sts.	11.97	20.12	11.01	2.64
Peking	14.83	12.28	16.00	2.67
Calcutta	15.01	14.72	11.00	3.02
San Francisco	15.21	14.72	12.08	4.15
Saigon	19.03	14.92	15.01	2.67
Cape Town	19.05	12.84	12.01	3.32
Honolulu	20.72	19.52	16.48	2.70
Buenos Aires	21.15	14.32	12.46	3.12
S.Pole	30.30	20.72	20.03	2.70
Christchurch	34,45	25.40	22.03	3.22

ranks across each population. These distributions are not normal; obviously those places at the near end of the scale show distributions of rank estimates with positive skew, those at the far end, negative skew. This is just a product of geometry. Table 3.1(b) shows rank orders for each population, constructed on the basis of increasing mean rank estimates, compared to the rank orders of places for the globe and the map. Tables 3.4(b) and 3.5(b) show the same thing for the Belfast and combined Edinburgh groups.

When it came to dealing with the distance figures, it became necessary to use medians instead of means. When estimating rank and confidence, subjects were restricted to the numbers 1-24 and 1-10 respectively; thus everyone's figures were on approximately the same scale of magnitude. But when it came to distance estimates there was no upper limit, and therefore no limit to the scale of magnitude employed by each subject in his estimations. As discussed earlier, each subject may have his own scale of estimation which will be quite valid for him; but this makes compiling group data in this way difficult and unreliable. For example, if the majority give their results in tens while one subject gives his in thousands, the estimations of the latter will have an undue effect on the means of the population as a whole. This was clearly illustrated by the E2 results; when the statistics were calculated for 45 subjects, the mean distance estimate for the South Pole was 26.16 . When one subject was dropped and the same mean calculated for the other 44 subjects, the figure was only 19.93 . The relevant standard deviation dropped from 44.22 to 6.37 at the same time. The B3 analysis showed for the distance estimations that the mean population skew for each place was +3.66, the lowest figure being +0.95 for Christchurch. With regard to the confidence figures, it can be clearly seen that the mean confidence estimate decreases with distance, which should occasion no great surprise. Again as a product of geometry, this distribution tends to be negatively skewed for near places and positively skewed for distant ones. It is interesting to note that the greatest uncertainty was expressed with regard to Saigon in three out of the four groups, this despite all the attention the city has received in past years.

Rank information has one great advantage in dealing with problems like the one in hand - being ordinal it does not suffer the scalar and logarithmic problems that beset cardinal estimates as previously discussed. However, there is also a great disadvantage in that rank data suffer from a lack of independence. If we ascertain that in objective canon X is closer than Y, and find that in cognitive analyses that Y is considered the closer, it is not possible to determine if this is because the distance to Y has been underestimated or because the distance to X has been overestimated.

In comparing the rank orders constructed from the mean rank estimates, a number of points can be made. Firstly, the three groups estimating distances from Edinburgh give basically similar patterns, although it would be difficult to calculate the significance of the divergences that can be discerned. This is due to the very strong natural trend in the data; one expects subjects to have no trouble distinguishing between places that are near, intermediate and distant (no-one is really going to estimate, say, New York as being more distant than the South Pole); it is only at the finer level of disaggregation that disagreements are likely to crop up. This disagreement in fact occurs in three areas of the scale, around 4th, 5th, 6th and 7th place, 11th and 12th place, and 15th to 19th place. These are areas where the actual differences in distance separating the places are naturally small, so this is not too surprising. What is interesting is that though one might have expected St Andrews to show the most differences, it shows striking agreement with the E3 scale, leaving E2 as the most divergent. And if it were thought that this was owing to the less attention paid to ranks by the E2 subjects, the E2 rank order is generally the more accurate! As further results will show, this is probably purely fortuitous. The difference most likely results from the fact that tied rankings were permitted in the E2 analysis; this would tend to blur the pattern slightly.

Of interest is the consistently low placing of Peking in all scales - it falls 22nd in all the Edinburgh based scales, as against its correct position of 16th, and is 21st on the Belfast list. The positions of Oslo and Paris are consistently reversed except for the B3 list. In this case, looking ahead to the distance estimate data, it would appear that underestimation of the distance to Oslo rather than overestimation of the distance to Paris is responsible. Other minor reversals occur as was expected - the correct order of Warsaw and Madrid is consistently inverted, as is that of Algiers and Athens. Interestingly, neither New York nor Honolulu are ever displaced from their correct positions. In the former case this suggests an accurate perception of the width of the Atlantic relative to the spatial extent of the Old World, but there is no obvious explanation of the latter.

Looking at the median distance estimates it can be seen that while estimated distance starts off by more or less keeping pace with actual distance, it levels off giving a logarithmic pattern to the whole. Since these median data are so awkward statistically, the task of determining exponents has been left until later when it can be tackled more appropriately.

There is not a great deal more to be said about this particular analysis. Its weakness lies in the fact that it attempts to combine all the data into a group image and then look for significant features. This is really putting the cart before the horse, and it is much more appropriate to examine the characteristics of the individual images and then see if these can be combined into a group image with any degree of significance. We shall therefore proceed to view the material in this way.

(ii) Accuracy Statistics

The difficulty of using rank order when studying individual places has already been mentioned; however, when we come to the matter of dealing with whole lists of places at a time, thanks to the elimination of scale problems, rank order analysis provides a useful means of comparing one set of estimates as a whole with a particular standard list. In particular it was desired to determine whether the rank order each subject gave more closely resembled the rank order obtained from great circle or map distances, and also to provide some comparative estimate of how accurately the correct rank order is represented. Accordingly a special statistic was devised, based loosely on Spearman's Rank Correlation Coefficent, and which we have christened the Accuracy Statistic and represented as AS. It is calculated on the basis of the squares of rank order differences according to the following formula:

$$AS = 1.474\sqrt{\sum(R_n - R_{Stn})^2}$$

where R_n is the estimated rank order for place n, and R_{Stn} is the standard rank order for the same place, where n is a number from 1 to 24. This statistic is, of course, specially tailored to this particular experiment, and would employ a different constant for lists of length other than 24. The formula is designed in such a way that the most accurate possible list, with all 24 places in the correct order, would score zero, while the worst possible list, in which the places were listed in inverse order, would yield a value of 100 . (This is the effect of the constant 1.474). A list in a random order will tend to give a value of 50 . For each subject, two versions of AS were calculated: AS with respect to the great circle distance rank order (this was labelled ASGC) and with respect to the rank order from map distances (this became ASMM). The calculations were computed by part of a large data analysis computer programme specially written for this experiment by Jurek Kirakowski and edited by the author; this programme also carried out most of the regression analysis discussed below. The values of ASGC and ASMM were then compared for each subject; the lower value indicated which standard the estimations more closely resembled. The next stage in the proceedings was to count up the number of subjects in each group with lower values of ASGC, and compare it with the number having lower values for ASMM. The significance of the majority so obtained was assessed by recourse to binomial probability theory. (Given a null hypothesis of no significant group image, it follows that the chances of a subject giving a lower value of one statistic or the other are equal; from there it is a simple matter to calculate the chances of r subjects out of n total all having lower values of ASGC or ASMM given equal probability of either occuring, i.e. a random distribution. If this chance is very small, we can express the confidence with which we can discard the null hypothesis as a percentage. This technique is effectively the same as the more common standard error technique, but in this particular context was felt to be more appropriate.)

The results of this analysis are presented as table 3.6(a). The figures for E3 and E2 are not really significant as they stand, but it is worth noting that the proportion of the total in each camp

Table 3.6(a)

ACCURACY STATISTICS -
GLOBE COMPARED TO MAP

Subject Group	Closer to Globe	Closer to Map	Significance (if>90%)
E3	13	8	
E2	24	19	
SA	40	20	99%
AL	77	47	99%
B3	16	40	99%

Tied results: E2, 1 subject; B3, 1 subject.

(All figures are number of subjects in each sample whose rank orders conformed most closely with that rank order.)

E3 = Edinburgh 3rd year students
E2 = Edinburgh 2nd year students
SA = St.Andrews's 1st year students
AL = Combined Edinburgh and St.Andrew's results
B3 = Belfast 3rd year students

Table 3.6(b)

ACCURACY STATISTICS -
SUMMARY

Subject Group	Mean	Standard Error	Median	Minimum Value	Maximum Value
E3	19.37	.94	19.78	11.61	28.88
E2	21.72	.89	21.03	7.94	34.98
SA	21.18	.85	19.99	11.42	44.90
AL	21.06	.54	20.11	7.94	44.90
B3	18.17	1.14	15.60	7.80	47.26

remains approximately similar. However, this proportion is only significant (unlikely to occur by chance) when the sample is of sufficient size, as the numerical difference between the opposing camps is a determining factor in the assessment of significance level. When the sample is as large as the SA sample, the same relative proportion becomes significant in absolute terms. What is unusual is that in the case of B3, although this relative proportion of majority/minority is numerically similar, the direction is switched; whereas ASGC gave better results in the Edinburgh groups, ASMM is favoured by the majority in the Belfast sample. This difference is quite possibly due to differences in the experiment. The differences between the two standard rank orders in the Edinburgh lists is more pronounced than in the Belfast list, partly because the shift of centre removes some of the anomalies in the Edinburgh lists, and partly due to the absence of the Bering Straits from the Belfast list. This place has a considerable effect, in that there is a wide gap between its relative position on the global list (where it appears in a medial position thanks to the transpolar distance) and its ranking on the map list (where it is placed far down owing to its peripheral position on the map). When a subject correctly perceived the distance as being transpolar, the large gap between the estimated rank of the Bering Straits and the map rank produced a large component of ASMM, giving ASGC an advantage. Of course, with the Belfast subjects this no longer occured with the Bering Straits off the list, replaced by a close city presenting no disparity between its two rank positions. This does suggest a limitation in this experimental technique, since the results seem to depend in too high a degree on the initial selection of places. However, this is no great loss, since other comparisons of map and globe are still to come.

The next stage was to derive descriptive statistics of the values of ASGC and ASMM, to see how accurate overall the subject groups were. The distributions for SA, AL and B3 were positively skewed by a significant amount, and so medians are included as well as means on table 3.6(b), which shows the results. The figures for E3, E2, SA and AL all refer to values of ASGC; those for B3 refer to ASMM. The calculations were performed by the SPSS Frequencies programme. Looking at the means, one can see the results to be fairly uniform, averaging close to 20 (a figure of 25 would be effectively "half-random"). However when the medians are considered, it becomes clearer that the E2 subjects are on the whole the least accurate, as might be expected from the variation in experimental procedure. That the group image for E2 was apparently more accurate than the others is now shown to be another example of mean data leading one astray. When the subjects are considered individually, they are found to be less accurate. The apparent accuracy of the group image might simply be a case of "theory of errors" - that non-cumulative errors tend to cancel themselves out. Table 3.6(b) presents mean description of individual data rather than individual description of mean data and is therefore more reliable. However, the margin of difference is not great and it would be unwise to put too much significance on this. As can be seen, the SA and B3 groups both contained subjects who were worse than any in the E2 group. The overall performance of the B3 group does seem to be notably better than the others. The E2 median is only 1.04 points behind SA, whereas the B3 median leads by 4.18 from E3. This is particularly interesting considering the tendency of the B3 results to approximate to map rather than to global rankings, but once again, it may be the experimental differences that are responsible. When the list of places was selected (with Edinburgh in mind as centre) a number of cognitive traps were laid (such as the Warsaw-Madrid one already mentioned). When the focus was shifted to Belfast, some of these traps were "defused", and the Belfast subjects therefore had an easier task before them.

(iii) Regression Analysis

Though the analysis of rank orders gives information about the ordinal cognition of distance, it tells us very little about the scale involved. More detail can therefore be obtained about the relationship between cognitive distances and great circle or map distances from a consideration of the Pearson correlation coefficents of the data. Whereas we were reluctant to use this means of analysis on the mean or median data, once we come down to an individual level it becomes much safer. For each subject estimated distance was correlated with and regressed against both actual great circle distance (abbreviated to AGCD) and actual Mercator map distance (AMMD). This provided two correlation coefficents (R) for each subject, measures of the strength of the correspondence between the patterns of estimated and standard distance; and values for the regression gradient (b), which shows the rate of change in the magnitude of estimated distance with increasing actual distance. This latter we might expect to vary from subject to subject as the scale of estimation involved may vary with subject as already discussed.

By comparing the two correlation coefficents obtained from AGCD and AMMD we can determine whether, as a whole, each subject's estimates bear a stronger relationship to global or map-based distance. In fact, for each subject four, rather than two, regressions were calculated for each subject. In order to take into consideration the expected logarithmicity of the data, as well as the regressions of estimated distance (D) upon AGCD and AMMD, the regressions of log D upon log AGCD and log AMMD were also calculated. For each subject the regression giving the highest correlation coefficent was selected, then for each group the scores were counted up and the number of subjects giving their highest values of R for each particular regression totalled. However, given the four-way split to the results the significance figures were assessed for two different pairings of categories, effectively great circle/map (irrespective of logarithmicity) and linear/logarithmic (irrespective of standard). These figures are presented as table 3.7 .

They provide a contrast to table 3.6(a) in that here there is a much greater degree of unanimity, the correlation with log AGCD being by far the most favoured by each group of subjects, including B3, which formerly appeared in the map-based camp. Even more impressive is the clarity with which the logarithmicity of the data is shown, thus confirming Bratfisch's results in this respect. This consistency is especially convenient with regard to the next major stage in the data analysis, to be dealt with in subsection (iv). Two conclusions can therefore be drawn from table 3.7: that the distance estimations gathered are significantly more logarithmic than they are linear in their relationship with real distance; and that of the attempted representations of the data, the logarithms of great circle distance provide a consistently better fit. This therefore suggests that the subjects were able to think about distances in terms of a round globe, and were not constrained to flat images.

The next step was to examine the regression gradients for each subject to see how much variety there was. We expected high variations between individual subjects on account of the likely variation in scale of estimation; also, from Bratfisch's evidence variation between groups should also be expected. Considering the

Table 3.7

CORRELATION RESULTS

Subject Group	Highest Correlation AGCD	AMMD	log AGCD	log AMMD
E3	2	2	12	5
E2	4	3	28	9
SA	6	3	40	11
AL	12	8	80	25
B3	1	2	33	21

	Any Gt.C.	Any Map	Significance
E3	14	7	90%
E2	32	12	99%
SA	46	14	99.99%
AL	92	33	99.99%
B3	34	23	90%

	Any log.	Any non-log.	Significance
E3	17	4	99.5%
E2	37	7	99.99%
SA	51	9	99.99%
AL	105	20	99.99%
B3	54	3	99.99%

AGCD = Actual great circle distance
AMMD = Actual Mercator map distance

Table 3.8

REGRESSION RESULTS

Subject Group	Mean b Value	Standard Error	Minimum Value	Maximum Value	Standard Deviation
E3	.88	.05	.57	1.38	.21
E2	.84	.02	.56	1.06	.15
SA	.87	.02	.44	1.24	.17
AL	.86	.02	.44	1.38	.17
B3	.88	.03	.43	1.54	.22

consistency of the results just described, it was decided to use just one regression gradient for each subject (log D on log AGCD) to facilitate comparisons. These were processed in the same manner as the AS results, by the SPSS Frequencies programme. The results, shown in table 3.8, are very interesting. The variation by subject is there as expected, with a total range in values of 1.11, but the consistency of the results from group to group is very striking, and bears no relationship to Bratfisch's results. In particular, it was hypothesised that the Belfast group, using a different standard only a quarter of the length of the Edinburgh/London distance, would show a different exponent of the subjective/actual distance relationship. This is not at all discernable. With regard to the skew of the distributions, that of B3 is negligible and that of AL virtually zero. This suggests that variation about the mean tends to be purely random, which seems entirely reasonable; there is no reason why this should not be so if we hypothesise that the variation in exponent is the result of fortuitous individual variations in estimating skills, which, like IQ, are likely to follow a normal distribution about the mean.

Since Bratfisch appears to have used a different method by which to arrive at his final exponent values, to wit, regressing all the data from all the subjects in each group simultaneously, it was decided that this method should be tried to see if it made any difference. It didn't. The answers were identical to those previously obtained, except for E3, which came out at 0.87 instead of 0.88, even closer to the overall mean.

We therefore come to the conclusion that though the exponents of distance estimation vary considerably from individual to individual, they were seen to be constant in pattern from group to group, even when focus and standard were changed. The mean about which the individual values fluctuated was stable at slightly under 0.87 . This may genuinely represent some element of the cognitive process, or it may just be due to basic estimation ratios not strictly linked to the actual perception of distance, but rather to its recall. It would take specific psychological studies to determine which.

One final point lies in the possibility that the consistency of the mean exponent value is a result of the scale of each experiment, not in terms of size of standard but in terms of range of distances, being kept constant. In each case the scatter of places covered the whole globe, from near at hand to the antipodes. Walmsley (1972) has suggested that differences in the range of distances may have caused the variation in exponents of emotional involvement to subjective distance in his own experiments, and between those of Gordon Stanley and the Stockholm investigators. It is possible that the constancy of range employed above may have had a similar effect in maintaining constancy of exponent, whereas a more limited range of distances might have produced a different exponent, but this seems less likely when we consider that Walmsley produces this hypothesis in order to criticise Bratfisch for constancy of scale, not inconstancy! So it does not look as though variation in range of distances explains Bratfisch's more varied results.

(iv) The Problem of Places

So far we have been looking chiefly at general images referring to the estimates made by each subject of the whole range of distances. By looking at the pattern presented by all the estimations of each subject we have tried to reach conclusions about the general way in which the world has been perceived by the subjects. However, this is only half the story, and we must now turn our attention to the crucial topic of the cognition of individual places. This is vital to our understanding of cognition as a geographical problem. It is not enough to study people as those who cognise the world; it is necessary to study places as objects of cognition.

Approaching the problem turns out to be quite tricky. Little can be deduced from a re-examination of table 3.2, place by place. If we take as a definition of overestimation at least one mean distance estimate exceeding either of the two correct distances, we can list the places that are ever overestimated. These are Dublin, Reykjavik, Warsaw, Madrid, Algiers, Moscow, Lagos, Bering Straits, Peking, Saigon and Cape Town; just under half the total. These are a mixed bag in that some of them are only overestimated with respect to map distances in cases where the map distance is much lower than the great circle distance, for example, Cape Town. If we take only AGCD as standard, the list drops to Dublin, Reykjavik, Warsaw, Algiers, Moscow, Bering Straits and Peking. All the distances beyond Peking are underestimated - comparable to the underestimation Stea found after the 4,000 mile mark. We are still faced with three problems. Firstly, what is to be done about places which are overestimated with respect to one standard and underestimated with respect to the other, or overestimated by only some of the groups; secondly, how can we judge the significance of the over- or underestimation, and lastly (but certainly not least), how much of the pattern of misestimation is a result of the already accepted logarithmic trend to the data?

The third of these problems gives the key to the solution of the other two. The superficial approach of scanning table 3.2 is just not sufficient. The median estimates are aggregates of widely varying data, and a more sensitive and discriminating approach is necessary. Again, it is important to assess the individuals and then generalise rather than to generalise the individuals and assess.

Take the case of a hypothetical subject whose estimates yield a cognitive/physical exponent of 0.5 . Quite clearly, most of his estimates are going to fall below the standard values; are we going to categorise him as having underestimated all the distances? In absolute terms, we could do so, of course; the statement, taken literally, is true. But we can also regard his data as exhibiting an exponent of 0.5, which is quite a different thing. If we say that he has underestimated all the distances, there is an implication that he could have overestimated instead, if perhaps, he had been given different places. There is a implicit suggestion that the distances themselves are in some way responsible, since there is no implication that the subject is to blame, or that he would have underestimated any distances. But if we say that the subject's estimates show an exponent of 0.5, the emphasis shifts to the subject. We are now saying that owing to the way this subject happens to make estimates, any distances given him will tend to be underestimated relative to absolute values. This does not involve the places as such at all; we can then go on to consider them separately. To clarify this argument, an illustration (figure 3.9) is provided.

This shows the plotting of the data from a hypothetical subject on a graph of D against AGCD (figure (a)). If we were to consider the subject's estimates in absolute terms, we would find twelve overestimations - the twelve points occuring above the line defined by D=AGCD ; all the other points fall below the line and would appear as underestimations. As the data is plotted on a graph with ordinary linear scales, the pattern of points is a curve. But the logarithmicity of the data is shown by the fact that when logarithmically plotted, the data conform to a straight line, as shown in figure (b). We have already conjectured that this logarithmic

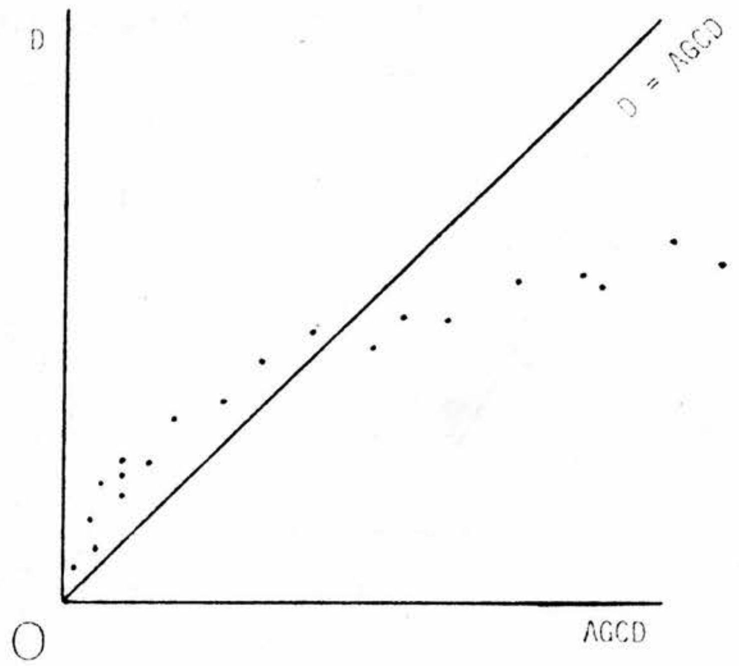


Figure 3.9 (a)

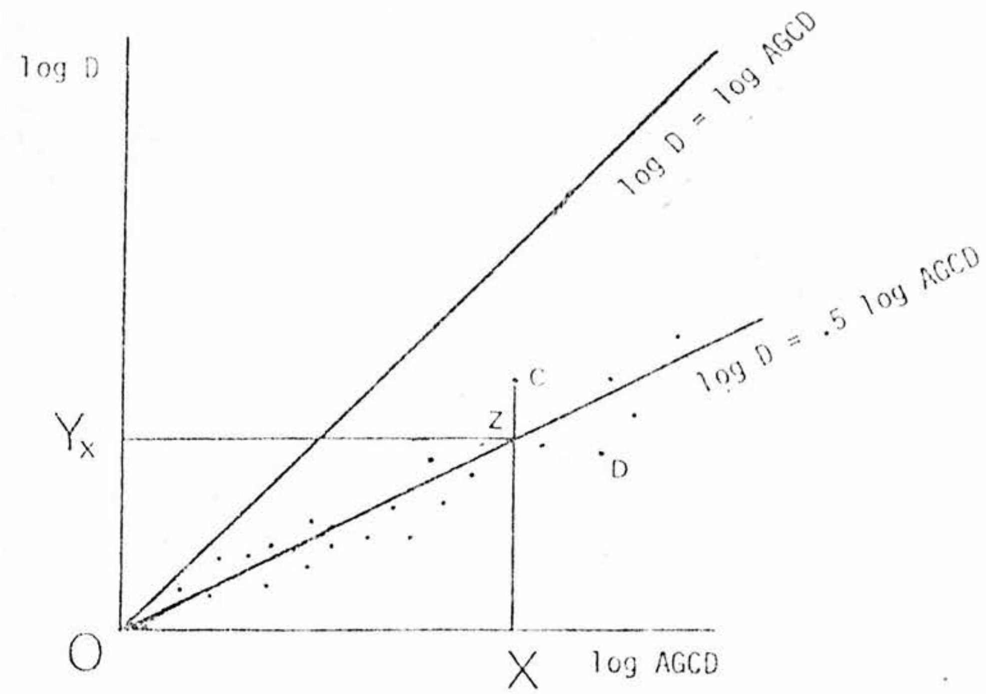


Figure 3.9 (b)

Use of regression analysis

pattern is a feature of the subject, not of the places. Either he perceives the world in a logarithmic fashion or he estimates in a logarithmic fashion; which of these alternatives is not actually important here - either way the pattern is characteristic of the subject and independent of the places. Therefore the use of a logarithmic graph loses no information about the individual distances themselves.

We now have to compare the points on the graph to the line $y=x$, that is, log D=log AGCD. We find that the log values for each place are consistently lower than the log standard distances. All the points are below the line. Having compensated for the logarithmicity of the data, we now find that all 24 distances appear to be underestimated.

The problem may appear to have been compounded, but this is only because the solution is not yet complete. If we take the regression of log D on log AGCD, we find that the best-fit regression line to the data is

$$\log D = 0.5 \log AGCD$$

and it is about this line that the points are clustered. The gradient of this line is the exponent of estimated distance that was discussed previously. (The use of the term exponent to signify the regression gradient stems from the alternative form of the equation whereby it is expressed as

$$D = AGCD^{b}$$

- this form of expression is favoured by Bratfisch). This exponent is directly comparable to the logarithmicity that we have just adjusted for; it is a characteristic of the subject and not of the individual distances. For this particular subject, the exponent value of 0.5 is an independent constant, and can be treated as such. Once again, the derivation of this constant, whether cognitive or otherwise, is not relevant. It is applicable to the entire list, and therefore does not affect the relative placings of the various distance estimations. We can therefore compensate for exponent in the same way as we did for logarithmicity, by changing the baseline. Instead of making comparisons with the standard values predicted by the line D = AGCD or the line log D = log AGCD, we now use the figures predicted by the regression line, which is log D = 0.5 log AGCD for this particular subject. In effect we are now saying that, given the way this subject estimates distances in general, that is, as a certain logarithmic ratio of the true distance, we would expect him to estimate the distance X (see figure 3.9) as Y_X, a figure derived from projecting the actual distance X onto the best-fit regression line.

For example, consider the point C in figure 3.9 . Its component representing the actual distance is given by the value X, and the line CX intersects the regression line at Z. Therefore, given the pattern of estimations made by the subject as best represented by the line log D = 0.5 log AGCD, we should expect that a place of actual log distance X ought to be estimated as being of log distance Y_X. (This can be translated into antilogarithms to obtain an actual predicted estimate.) Therefore the place should be represented on the graph by point Z of co-ordinates (X,Y_X); in fact it isn't, since C exceeds the predicted value by CZ. Although the point C appears to represent an underestimation when compared to actual distance and log actual distance, when compared to the way the subject actually estimates distance, it represents an overestimation. The point D in the diagram is a point which indicates a distance underestimated in comparison with its predicted value.

If we now take the case of a different hypothetical subject whose figures yielded an exponent of 1.5, though his estimates might at first seem all to be overestimations, and far higher than those of the first subject, by applying the same process we can reduce the scale of his estimations so that the actual pattern of genuine overestimation and underestimation can be compared directly with that produced by the first subject. Having removed all the variations in estimates stemming from the various subjects themselves, we have at last isolated the pattern that is directly contributed by the individual places. It will also be noted that the consistency of the logarithmic pattern previously revealed greatly facilitates this analysis, in that it becomes valid to hypothesise that those graphs which gave higher correlation coefficents for simple linear regressions were chance aberrations, and that it is possible to regard all the data as inherently logarithmic and therefore to treat it all in the same fashion.

So, we have proposed that the pattern of regression residuals is equivalent to the pattern of true underestimation and overestimation. This, it is suggested, is caused by the individual cognition of individual distances. But let us suppose for a moment a null hypothesis - that places have no especial effect on cognition at all. What then of the residuals' pattern? In the case of a hypothetical ideal subject, the points on the graph would then all lie along the regression line - there would be no residuals at all. However, the ideal subject exists more in imagination than in reality; there will still be residuals, only they will be the product of pure chance, sometimes falling under, sometimes over the line, the direction depending on mere accident. How then, do we distinguish the residual that represents a real cognitive misestimation and the residual that is there only because it has to be somewhere?

The answer if fairly simple. Given only one subject, one image, nothing significant can be determined. Given a large number of subjects, by comparing the patterns produced by each we can determine whether a valid general image can be construed for any particular distance by looking for consistency in the direction of residuals. If the direction of residuals (positive or negative) is produced by pure chance, the probability of one person overestimating the distance to X is 0.5 . The probability of r people out of n all overestimating the difference to X by mere coincidence can be calculated by the binomial theorem as before, and significance figures derived. If the chance of a discovered agreement turns out to be very small, say less than 0.01, then we can say with 99% certainty that the consistency of direction represents a genuine cognition of that place being too close or too far away.

This has dealt with all the problems except for one: what should be done about the two different distance standards, the great circle and the map distances? Supposing an estimation represents an overestimation with regard to one and an underestimation with regard to the other? It would be possible to regard the map scale as having been overruled by the support given to the great circle scale, and ignore map distances altogether, but to do so at this stage would be unjust. The distinction between great circle scale and map scale is different from the logarithmic/linear problem just dealt with, for whereas the logarithmic pattern of any subject is a constant throughout, map perception may be something that is localised to particular distances, so that though the subject's overall pattern conforms more closely to global standards, it is possible to identify particular places that have been thought of in map-like terms.

The problem was tackled in this way. For each subject, two regressions were obtained, that of log D on log AGCD and log D on log AMMD. Residuals from both these regressions were tabulated in a 2n x 24 matrix (where n = no. of subjects). Then for each place, the residual with the lowest absolute value was selected from the two produced by each subject. This produced a matrix n x 24 of residuals some of which referred to the AGCD regression and some of which were derived from the AMMD regression. Which residual came from which regression was recorded on another matrix. We have christened this technique of combining two regression analyses "parallel regression". The advantages are twofold: firstly, it permits of two possible interpretations of any particular distance estimation, in the context of globe or of map; secondly, by minimising the possible size of the residual and the distance of the point from the line, the technique constrains the data in the direction of the null hypothesis as much as possible, which will lend greater weight to any positive results which would appear to contradict the null hypothesis.

Having obtained the composite matrix of residuals, each place was assessed on the number of times it appeared as a positive residual and the number of times it appeared as a negative residual, and the significance of the result was assessed on the basis of binomial calculations. These figures are entered as table 3.10.

The results are quite impressive. The first thing to note is the consistency of the figures with regard to each place. If one group shows a positive figure for a particular place (representing overestimation of that distance significant at the given percentage level), no group will show a negative figure for the same place. In other words, each distance is either significantly overestimated by some or none of the groups or significantly underestimated by some or none, but never significantly overestimated and underestimated by different groups. Each place engenders an image that may vary from group to group with regard to strength but never with regard to direction. And of course, some places are perceived correctly, or at least, the errors average out at an estimation approximating to the predicted value.

Table 3.10

ANALYSIS OF RESIDUALS
(Significance from frequency)

Place	E3	E2	SA	AL	B3
Dublin		+90%	+90%	+95%	np
Paris			-95%		
Oslo	-99.5%	-95%	-99.9%	-99.9%	-99.9%
Reykjavik					
Warsaw		+90%	+90%	+95%	
Madrid					-90%
N.Cape		-99.9%	-99.9%	-99.9%	-99.9%
Algiers	+99.9%	+95%	+99.9%	+99.9%	+99%
Moscow		+99.9%	+95%	+99.9%	
Athens	-90%				-95%
N.Pole		-99%	-90%	-99.9%	
Jerusalem					
New York		-95%		-99%	
Lagos	+90%			+90%	+90%
Bering Sts.	-90%	-95%	-95%	-99.9%	np
Peking	+99.9%	+99.9%	+99.9%	+99.9%	+99.9%
Calcutta	-95%		-90%	-90%	
San Francisco	+95%		+95%	+99.9%	+99%
Saigon		+95%	+90%	+99.9%	+99.9%
Cape Town					-95%
Honolulu		+95%	+95%	+99%	
Buenos Aires			-95%	-95%	-99%
S.Pole				+90%	+90%
Christchurch	-90%		-90%	-90%	-99.9%

KEY
- indicates underestimation
+ indicates overestimation
Percentage figures show significance
(values >99.9% are treated as 99.9%)
np = not placed in Belfast questionnaire

This means that of the first four columns of table 3.10, the fourth is the most important, being the amalgamation of the preceding three and therefore the largest sample size. Since the previous three are not usefully different, there seems no advantage in not representing them chiefly by the AL column. Before we do this, though, it is interesting to make a comparison of the strengths of images by seeing which places are significantly placed in all columns. As can be seen, Oslo is invariably underestimated by all groups, but Reykjavik is never significant. The Bering Straits distance is heavily underestimated (except, of course, by the Belfast group since it was omitted from the Belfast list). Algiers and Peking are overestimated right across the board; the distance to Jerusalem is approximately correct (this exactitude with regard to Jerusalem was a notable feature of the pilot experiment also). Both Cape Town and Madrid only appear significant in the Belfast column, and then relatively weakly.

The next thing to notice is that we have lost the trend towards increasing underestimation with increasing distance. The most underestimated distance is only the third shortest, and underestimations and overestimations are equally spaced out down the list. Since we have shaken off the problems of logarithmicity and scale, and isolated the estimations of individual distances, we can now look more closely at the question of barriers. However, this we shall leave until sub-section (v).

It was decided to attempt to back-up the significance figures in table 3.10 by examing the size of the residuals. Given that the distribution of residuals for any particular place is not necessarily normal, there is no reason why a case like figure 3.11 should not occur, where, although all residuals are greater than zero, thus giving (on frequency) a very significant result, the magnitude of the

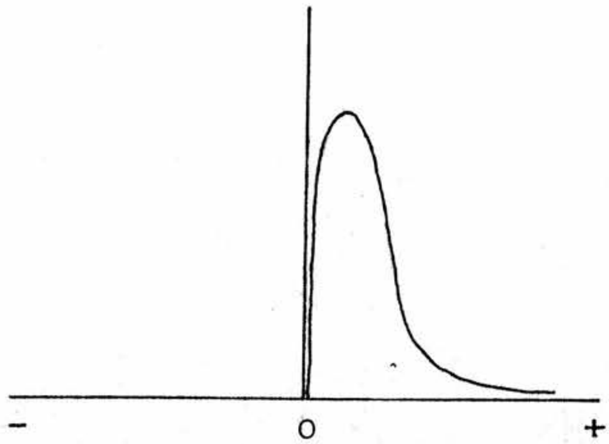


Figure 3.11

First hypothetical distribution

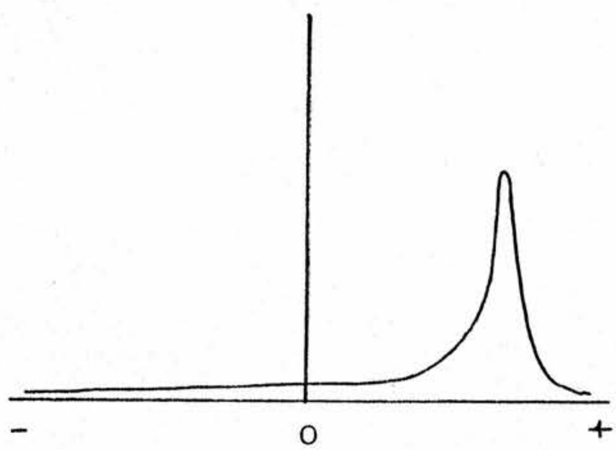


Figure 3.12

Second hypothetical distribution

overestimation is not very great. By contrast, figure 3.12 represents a distribution which would give a lower significance figure on frequency of overestimation, but a higher mean residual.

The following procedure was adopted. The mean residual for each place in each group was calculated, and if it was more or less than zero by two standard errors or greater, a plus or minus was accordingly noted. The use of two standard errors as a measuring stick was semi-arbitrary. In a normal distribution this would represent the bounds within which the true population mean (as opposed to the sample mean) would be likely to lie 95% of the time. The figure of 95% does not necessarily hold for non-normal distributions, but the standard is a useful one, since it will certainly eliminate cases resembling figure 3.11, which is all it is intended to do. The results of all this are presented as table 3.13 . Comparison of this with table 3.10 shows that the results are fairly consistent. Dublin is undermined in the significance of its results (not entirely surprisingly, since the estimates are necessarily small anyway); so is San Francisco, Saigon and Honolulu. The significance of the South Pole figures is backed up slightly more, as is the case with Paris and Moscow - otherwise the figures are much the same. The next step was to analyse how frequently the lowest modulus residual came from the AGCD regression and how often from the AMMD regression. This was calculated for each subject, and the significance of the consistency assessed as before, by reference to binomial probabilities. The total number of subjects with significantly consistent lists of residuals (at the 90% level or greater) was a mere 32 out of 182 . Twenty-six of these approximated consistently to great circle distances. This is quite interesting in that it somewhat undermines the earlier results on general images; it suggests that there are two levels of significance involved. For

Table 3.13

ANALYSIS OF RESIDUALS
(Significance from size)

Place	E3	E2	SA	AL	B3
Dublin					np
Paris			-	-	
Oslo	-	-	-	-	-
Reykjavik					
Warsaw		+	+	+	
Madrid					
N.Cape		-	-	-	-
Algiers	+	+	+	+	+
Moscow		+	+	+	+
Athens					-
N.Pole	-	-	-	-	
Jerusalem					
New York		-		-	
Lagos			+	+	
Bering Sts.	-	-	-	-	np
Peking	+	+	+	+	+
Calcutta	-		-	-	
San Francisco					+
Saigon				+	
Cape Town					-
Honolulu					
Buenos Aires		-		-	-
S.Pole			+	+	+
Christchurch			-	-	-

KEY
- = significant underestimation
+ = significant overestimation
np = not placed on Belfast questionnaire

each subject, by and large, one image will not be a more significant representation than the other, but for a group of subjects, one standard will yield significantly better results. Great circle distances may come out on top for a significant majority of the subjects, but for each of them the margin by which it supercedes map distances is not significantly great. This lack of consistency within each individual directly suggests that the individual places have a strong bearing here; certain distances may lend themselves to map perception whilst others are conceived of in global terms by the same subject. In this case our earlier "general images" are somewhat of a necessary evil - a stage in the analytical process more than a reflection of the results. Rather than it necessarily being an intrinsic property of each subject that he should be a "map-perceiver" or a "globe-perceiver", it seems that the emphasis is more on place than person, that there are distances easier to cognise in map terms or in globe terms. The general image that an experiment unearths may therefore necessarily be a product of the selection of places that one makes. This throws interesting light on the earlier discussion of the difference between the Edinburgh and Belfast rank orders, and may explain the disparity a little more clearly.

Obviously the next question to ask is which places were consistently associated with one or other regressions? This is not something that can really be adequately determined. The disadvantage of the parallel regression technique is that although it does allow for two different ways of interpreting the distance estimates, by reference to globe or map standards, it does not necessarily follow that if a place is assigned to one regression by dint of lower residual, one can invariably assume that the subject had that particular distance scale in mind. Of course, in most cases it is probably true to say that if a significantly lower residual occurs on a map regression then that represents a reference to map distance. But it is theoretically possible for a distance estimation, which, in isolation appears to relate to one sort of distance standard, to be represented by a lower modulus residual in the opposite regression if it corresponds more closely to the general trend of that regression. This is most likely to occur in extreme cases where there is already a very strong trend to one or other distance standard, which will tend to swamp minor divergences. Since the technique has been constructed on a fail-safe basis, that is, minimising the significance of results, this is not seen as a major weakness. There is a further difficulty in examining preferred projection in that, if an estimate is grossly in excess of both actual distances, it will naturally tend to give a lower residual with respect to the larger of the two. It would be unwise to attribute this consistency to the projection as such, but rather to the relative size of the two standard distances. If the difference between these is considerable, then it may be true to say that the discrimination between map and globe is a valid one.

Bearing these limitations in mind, one can examine table 3.14, which indicates the places for which the selection of residuals was consistent. It can be seen that the images for each place tend to be consistent, the most notable exception being Peking, and the only other ones the slightly significant Cape Town and Jerusalem. In the face of the other results it may be possible to regard this exception as a chance aberration of limited interest. Detailed interpretation is not easy. Perhaps the most notable thing is the tendency to map distances round the periphery: Honolulu, San Francisco, Buenos Aires, Cape Town and Christchurch. While subjects might be aware that the distance to Bering Straits is trans-polar, it is more difficult to realise the effect the girth of the globe has in lengthening the

Table 3.14

CONSISTENCY OF IMAGE WITH PLACE

Place	E3	E2	SA	AL	B3
Dublin					np
Paris			M90%		
Oslo	G95%	G95%	G99.9%	G99.9%	G99.9%
Reykjavik		G95%			
Warsaw		M90%	M99%	M99%	
Madrid					M95%
N.Cape	G95%	G99.9%	G99.9%	G99.9%	G99.9%
Algiers	G95%	G99.9%	G99.9%	G99.9%	G99.9%
Moscow		M99%	M99%	M99%	
Athens					M90%
N.Pole		G99.9%	G99.9%	99.9%	G99%
Jerusalem			G90%		M90%
New York					
Lagos	G90%				G95%
Bering Sts.					np
Peking	G99.9%	G99.9%	G99.9%	G99.9%	M99.9%
Calcutta	G99.9%		G99%	G99%	
San Francisco	M90%	M90%	M95%	M99%	M95%
Saigon		G95%	G95%	G99%	G99.9%
Cape Town	G90%	M95%			M95%
Honolulu		M95%		M95%	M99%
Buenos Aires		M95%		M99%	
S.Pole			G95%	G90%	
Christchurch	M90%		M95%	M99%	M95%

Edinburgh	G95%
London	G95%

KEY
M = tendency to map image
G = tendency to globe image
Percentage figures indicate significance levels
np = not placed on Belfast questionnaire

distance to somewhere like Buenos Aires, especially when this distance is not obviously distorted on most maps, as is the distance to the South Pole on Mercator's projection. At an earlier stage in the analysis, when residuals had been compiled for only one regression (the one with log AGCD), one of the most spectacular features of the data was the massive underestimation of the distance to Buenos Aires. Once the parallel regression technique was introduced, this was dramatically reduced. Measuring such a distance with a tape measure on a large globe can be a very educational experience as one sees just how the bulge of the Earth at the equator affects distances to the southern hemisphere.

Perhaps the most important conclusion from table 3.14 is that it does seem to show that consistency of image by place exceeds consistency of image by subject, as previously suggested.

Before going on to consider the interpretation of the individual estimation results in terms of geographical factors, it will be appropriate to turn back to the figures collected for the confidence expressed in each estimation. It was regarded as a possible hypothesis that the variations in accuracy shown as greater or smaller residuals were occasioned by variations in awareness about which the subject was under no illusions. Under this hypothesis, for each subject, the modulus residuals and confidence figures should have a high covariance, and this was tested for by regression analysis.

The results showed that very occasionally this might be true for isolated subjects (one subject had as much as 39% of the variation in his residual figures explained by his confidence estimates) but in general the mean explanation provided by confidence estimates was 1% or less. Furthermore, almost as many subjects gave inverted correlations as gave predicted ones; in general terms the significance of confidence in explaining misestimation as measured was nil. Figures were also obtained for the correlation of confidence with percentage error, derived as estimated distance divided by AGCD or AMMD and multiplied by 100 . These are not significantly better.

The final topic to be covered is the attempt to explain the obtained estimations in terms of the places themselves and the nature of the distances that separate them.

(v) Barriers

Once we start looking at the pattern of estimations in terms of barriers, then we are beginning to look at the subject with a truly geographical perspective. We are looking for evidence of the perception of distance being guided by the geography of that distance, either in terms of the attributes of the place itself, or of the attributes of the distance to that place; attributes that may be physical in terms of seas or land masses, or may be human as with political boundaries or language divides. Also, we are beginning to hypothesise that subjects estimating distance may be subconsciously asking themselves "what lies between here and X?" in terms of perceptual events; that it is necessary to cross into another continent, or cross the Iron Curtain, or whatever. In other words, the concept that Stea introduces into this field under the heading of "barriers" is the start of the hypothesis that geographical space may be perceived or measured by the things it contains - a tacit association of space and matter.

Returning to table 3.10 once more, let us consider in the light of it the three sorts of barriers that Stea investigated. The first of these was marine barriers - separation of the various places by bodies of ocean or sea. The first test of this was the comparison of Oslo and Paris - the first of these distances is chiefly across sea, the second mostly across land. Accordingly, one might expect the distance to Oslo to be overestimated relative to Paris. Of course, as the results show, the reverse is true. New York, an important inclusion in the list as one of the closest cities of the New World, separated from Britain by the Atlantic Ocean, is again underestimated rather than overestimated. On the other hand, a predominantly overland distance like that to Saigon, is overestimated. The general impression given by the results is that marine barriers do not exist in the expected sense; rather that land barriers are more probable phenomena. One could, however, think of seas as a sort of "negative barrier", causing underestimaton, if one wished.

There are two ways of regarding this. The first is to account for it culturally, and hypothesise that while British subjects might give such a result thanks to a long naval tradition which might still gear people to thinking of foreign places as "overseas", and of seeing little obstacle in a sea journey, it might be that American subjects, given that the dominant American cultural tradition is of an overland, pioneer outlook, might regard the ocean as much more of a separating barrier. The sea is an ambiguous agent; it can divide but it can also unite. The other approach is to look at this effect in more philosophical terms. The basis of "barrier thinking", as has already been discussed, is the concept of space viewed in terms of its contents. The contents of x miles of land are both varied and variable - there are rivers and mountains to cross, cities to pass by, countries to pass through. The contents of x miles of sea are uniform and unchanging - a large amount of water, showing blue and unfigured on the map. Measuring by events, a land distance ought to be perceived as more distant, for it contains more perceptual events to be crammed into the same space. The sea contains but one event - itself. Of course, it is also true to remark that monotonous distances often seem boring and therefore longer, but that is an experiential approach, and at this level we are dealing chiefly with non-experiential cognitions.

With regard to political barriers, one must be a little more selective, since all the distances, unlike those in Stea's experiment, cross at least one political boundary, and to count all those crossed is obviously not appropriate. Whether the great circle route to Cape Town intersects the boundaries of Botswana or not, in addition to all the other frontiers it crosses, is highly unlikely to have any effect on cognition. On the other hand, there are other political boundaries of note besides state borders, to wit, the "ideological" frontiers of the Iron and Bamboo curtains, and these do look as though they might be associated with overestimation.

Finally, we have Stea's lingual barriers. It is difficult to discern any pattern, positive or negative, with regard to these in table 3.10 . However, once again, we would expect only one barrier would be effective in affecting any distance estimaton. It seems unlikely that all the different intervening lingual areas lying along a route would be comprehensively cognised, but it would be easily noted that a different language was spoken at the end point of the distance.

Having looked at these superficially, it was next decided to try and synthesise the barrier concept in a single barrier score for each place. This was calculated as follows:

(a) Lingual barrier. If English was not a major language in the object place, one point was awarded. Cities like Cape Town and Calcutta were therefore not given the point, even though the chief languages of these cities is other than English. Places in polar latitudes where no language is spoken much were not given the point.

(b) Ideological barrier. If the place had a communist government it was given one point. Saigon was not given the point since it was felt that the government there was too recently established to have been cognitively registered. The author hastens to point out that this discrimination against communist countries rather than, say, fascist countries, is no political bias, but purely due to the fact that left-wing governments are more prone to making it difficult if not impossible for the foreigner (or native, for that matter) to cross the country's borders. It can also be justified on the grounds that the American division of the world into "free countries" and "communist bloc" has an effect on colouring geopolitical thinking in this country.

(c) Land barrier. One point was awarded for each continent traversed in substantial amount by the distance in question. This was considered as justifiably cumulative unlike the lingual and political barriers owing to the fact that land barriers, larger and more indisputable, are self-evident on any map. In addition, a bonus point was awarded for each continental boundary crossed (e.g. Europe/Asia, Europe/Africa), provided this was not an ocean. It was felt that, for example, Algiers might be cognised as being too far away owing to its being outside Europe, whereas New York would not show the same effect since the Europe/America boundary might be considered as cancelled out by the negative effect of the ocean. The judgements on the total score awarded were occasionally a little subjective: Honolulu totalled one for the North American continent crossed; Christchurch received one for Europe, one for Australasia and one for rather tangentially intersecting Asia, making three in all; Moscow was awarded a point for the amount of Europe crossed to reach it, whereas Warsaw was not. These figures were usually based on map routes rather than great circle routes.

(d) Cultural association. This was added in a rather negative sort of way, in that places formerly under British administration had one point deducted from their score. The same effect could be achieved by adding one point to the score of all the other places on the basis of a cultural barrier, so the negative aspect need not worry us with implications; it was simply felt to be a more direct way of achieving the same ends. New York had a point deducted whilst San Francisco did not (1776 and all that). The point was not deducted from Jerusalem, though it might well have been, considering the former British involvement with Palestine.

The final figures were therefore as follows: Dublin -1, Paris +1, Oslo +1, Reykjavik +1, Warsaw +2, Madrid +1, N. Cape 0, Algiers +3, Moscow +3, Athens +2, N. Pole 0, Jerusalem +2, New York -1, Lagos +2, Bering Straits 0, Peking +5, Calcutta +2, San Francisco +1, Saigon +4, Cape Town +2, Honolulu +1, Buenos Aires +1, S. Pole +3, Christchurch +2. This list was regressed against the median residual for each place, acquired from the calculations of the AL group. The resulting relationship was the equation

$$y = 0.06x - 0.08$$

for which the value or R was 0.66, a value significant at the 5% level. This is equivalent to over 43% of the general residual pattern being explained by this admittedly crude measure of barriers, which, as can be seen, tends to the hypothetical and subjective. Certainly this is a much better result than that obtained from using confidence estimates as an explanatory variable (discussed earlier). The reason why medians were processed for the AL subjects as a whole, rather than treating each subject individually was chiefly that, given the blunt nature of the hypothesised barrier scores, it would be inappropriate to attempt to use too fine a level of disaggregation in the analysis. The B3 data were not processed separately, since they resemble the AL data sufficently closely for us to regard this as superfluous.

There is, of course, room for manipulation. Having seen little evidence for lingual barriers in table 3.10, we re-did the calculation without the lingual component. The result was a lower value of R (0.56), thus suggesting that lingual barriers do have at least some effect.

In conclusion, it should be said that for such a vague construction to yield such a good result is most promising. It suggests that there is potential here for further research, especially into the detailed cognition of barriers at a global level, and a determining of the relative parts that different sorts of barriers play. It certainly seems that barriers or perceptual events play an important part in the cognition of global distance.

5) PSYCHOPHYSICS

In the course of the preceding text, we have occasionally touched on matters relating to a particular branch of the discipline of psychology without giving much consideration to the psychologist's point of view. In the following section the author hopes to remedy this by giving a brief account of the relationships between some of the preceding arguments and the study of psychophysics. It has been thought advisable to keep this discussion separate from the rest of the text since, to most geographers, the field of psychophysics is a trifle obscure; it is thus easier to follow the whole of the discussion, or to skip it.

Psychophysics was originally conceived of as the science of relations between mind and body; but since this gives it rather a philosophical scope, it is perhaps easier to describe it as the study of the relationships between psychological and physical phenomena, mental entities and the stimuli that produce them. It has also been described as the science of relations between psychological dimensions and physical dimensions, thus emphasising the psychophysicist's essentially metric viewpoint. The search is always for laws dealing with numerical transformations between a physical dimension and some form of psychological dimension.

In particular, we are concerned with perceptual psychophysics, which is concerned with the relationships that dimensions of physical stimuli bear to the dimensions of sensation of those stimuli, for example, the relation of perceived brightness of light to the actual intensity of light waves, or the sensation of salinity to the actual concentration of salt solution. And, of course, the relationship between perceived length and actual physical length.

In historical perspective, psychophysics can be divided into the "old" psychophysics of which Fechner was the chief exponent, and the "new" psychophysics established by S.S. Stevens. In recent times, C.W. Savage has attempted to demolish both these positions in favour of a "radical" psychophysics, about which more will be said later. Fechnerian psychophysics revolves largely around the concept of the "jnd", or just noticeable difference. This more or less self-explanatory term is simply the least amount of change necessary in a stimulus for an observer to be able to perceive that a change of a very small nature has, in fact, taken place. According to Weber's law, which is in many ways the foundation of the Fechnerian edifice, all just noticeable differences are equal, and are equal to a constant proportion of the stimulus in question. To a certain extent, this is obviously observable. In a room lit by one candle, the addition of a further candle occasions an easily appreciable difference in illumination. However, in a room lit by a hundred candles, one more candle will not make a sufficent relative increase in brightness to be noticeable.

Similarly, in section 2 subsection (iii) (q.v.) we argued that certain ratios were more easily distinguished from others in the search for an explanation of the logarithmicity of estimation. We were, in fact adducing from Weber's law, or at least, the part of it that works. The illustration given by the example of the candles does indicate that the jnd is relative to the stimulus magnitude and not constant in terms of absolute units, but it does not show that the jnd is a constant fraction at any scale of magnitude. Suppose we find that adding a 54th candle to 53 is just noticeable and no more. Will the same hold for adding the 54th 100 candles to 5300? Not only has this never been proved, many would say that it does, in fact, not hold at all; that just noticeable differences are not equal at all scales of magnitude.

Nevertheless, Fechner proposed a system by which the jnd could be used as a basis for the measurement of sensation; at that time, this was a notable advance since it had previously been held that sensation was not susceptible to measurement at all. He also propounded Fechner's law, which, (slightly paraphrased) states that:

$$(\text{sensation}) = k \log(\text{stimulus})$$

where k is a constant, the value of which depends on the sort of sensation in question. This law is developed mathematically from Weber's law.

There are many objections to Fechner's position, and a wholesale critique is not relevant here. Two examples will suffice. Firstly, if one uses jnds as a basis for measurment, one cannot then use one's measurements to prove that jnds are equal without being guilty of circularity; therefore, given no other method of measuring sensation, one cannot vindicate the basis of the whole system, namely that as jnds are equal, they can be used as the basis of a system of measurement. Secondly, there is a tacit assumption that in a particular experiment a jnd can be accurately determined. In fact, there is probably a zone of uncertainty, and an observer may think he notices a difference on some occasions, and on other occasions be less sure, given exactly the same experimental conditions on each occasion (Savage, 1970).

The theories Fechner laid down were subjected to intensive debate for many years, but it was only until the work of S.S. Stevens on ratio scaling that there arose a comparable body of theory to replace the Fechnerian doctrines. Stevens devised many techniques for investigating reaction to stimuli using ratio estimations, and the results of these experiments led him to believe that, rather than reaction following a logarithmic pattern as proposed by Fechner's logarithmic law, it showed a pattern that suggested a power law. We therefore have the relationship variously described as "Stevens' power law" and "the psychophysical law":

$$(\text{sensation}) = (\text{stimulus})^n$$

where n (the exponent) is equivalent to the constant k in Fechner's law. It should be noted in both these laws that we have taken a slight liberty in representing the two components as "sensation" and "stimulus". Strictly speaking, one should read "a psychological dimension in units of psychological measurement" for "sensation" and " a physical dimension expressed in units of physical measurement" for "stimulus".

It should also be noted that the relationship between perceived distance and actual distance already discussed is effectively another instance of Stevens' power law. The forms

$$\log D = b \log AGCD$$

and

$$D = AGCD^{\,b}$$

are synonymous. We have preferred to use logarithms since the equation was derived primarily from a graphical portrayal of the data, which were processed by regression analysis to obtain the appropriate formula. Stevens, on the other hand, probably wanted to avoid confusion with Fechner's "logarithmic" law (but which has logarithms on one side of the equation only); furthermore, he also derives the law as it stands from mathematical reasoning, using as basis a variant on Weber's law. He does indicate both forms of the equation (Stevens, 1957).

Since the Swedish investigators previously discussed in section 1 are all psychophysicists of the Stevens school, the above sheds some light on their approach to the subject, as follows:

(i) (A trivial point.) It explains the different renderings of the subjective/physical distance equation used by Bratfisch and the author. Bratfisch sees it in the lineage of Stevens' law, whereas the author prefers to express it in terms of a straight line on a logarithmic graph.

(ii) It perhaps explains the apparent lack of interest shown by Bratfisch et al. in determining the independent variable in the subjective distance/emotional involvement equation. It may be that having confirmed the psychophysical law once again by discovering a power function, they regard this as the conclusion of the matter.

(iii) It illustrates more clearly Lundberg's criticism of Stanley. Since the psychophysicist is concerned with the measurement of sensation, it is the "sensation" of distance that is important to him, not the extent of information upon it. If the subject can say that Paris "feels" that much further from London, well and good; the experimenter is satisfied that he is dealing with a psychological dimension. If, on the other hand, the subject knows that Paris is that much further from London, the "psychological dimension" is spurious in so far as it is just an extension of the physical dimension of distance. Of course, as previously argued, the extent to which the psychological and the physical can be divorced by the subject is an unknown variable. Since we have shown that there seems to be an important geographical component to cognitive distance, it may be that the psychophysicist must proceed with care when venturing into geographical waters.

However, we now have to deal with one of the thornier problems in psychophysics, one which has significant reference to some of the preceding arguments relating to data analysis and experiment design. The question is fundamental: can sensation really be measured? Since Stevens has by and large disposed of the Fechnerian principles of sensation measurement, it remains to deal with Stevens' own techniques - the ratio scaling approach. In this technique the experimental procedure is very roughly as follows: the subject is shown two stimuli and is asked to estimate the ratio of the two magnitudes as he perceives it. This may be the length of two rods, brightness of two lamps, or whatever, as the case may be. The phrase "as he perceives it" is really dispensible, since the subject can scarcely produce a sensible estimate of the ratio as he doesn't perceive it. The basic premiss is that the stimulus produces a sensation, the subject estimates the sensation, reports this to the experimenter, who can then say he has measured the sensation. However, as Savage argues in his broadside against conventional psychophysics (Savage, 1970) this is not so, since the experimenter has no way of independently assessing the subject's accuracy of estimation relative to the sensations produced by the stimuli. He can compare the ratio estimates with stimuli, but not with sensations, and since he cannot check the accuracy vis a vis the sensation he cannot say he has measured (i.e. measured accurately) sensation.

According to Savage, there are two possible interpretations of the ratio scaling technique, the introspectionist and the behaviourist, and he criticises both of these. The introspectionist position states that there do exist private "sensations", psychological phenomena, and that the subject can estimate the size of these psychological phenomena apart from estimation of the physical stimuli. Savage attacks this position from two directions. Firstly, he argues, these internal psychological phenomona do not really exist, and that to ask a subject to estimate the length of the visual sensation produced by rod A without estimating the length of rod A is ridiculous. Secondly, even if they did exist, we could not measure them, owing to the difficulties detailed in the preceding paragraph.

The behaviourist approach is to take the attitude that "measurement" is basically a process of simply assigning numerals to phenomena, and this is being done. Whether the estimates given refer to inner mental entities is not relevant; what is important is that the subject has chosen to give those particular numbers to those particular stimuli; the ratio estimates can therefore be investigated in their own right. Unlike the introspectionist position, this approach is logically quite sound. However, it does have implications. If the "mental entities", the psychological phenomena, are not integral to the ratio scaling proceedure, they, and by and large sensation as well, are irrelevant altogether. Under the behaviourist approach it is unneccessary to posit any psychological phenomena at all - one is really subjecting the subject to physical stimuli (expressable in physical units) and receiving from him "physical estimates" (also expressable in physical units). Far from measuring sensation, the power-law experiments would seem to measure what Savage calls "perceptual abilities" - and this term is by and large synonymous with "process of estimation".

The adherents of Stevens seem to take the attitude that a subject presented with two stimuli perceives the ratio between them in an inaccurate fashion (i.e. other than the objective physical ratio) and then estimates this perceived ratio with complete accuracy. To this non-psychologist at any rate, it would appear that the contrary is far more plausible: that the subject perceives the stimuli quite accurately, but (as previously argued) estimates them inaccurately. The hypothetical experiment previously suggested, in which subjects completed a distance estimation questionnaire while looking at a map was regarded by the author as an investigation of how people made estimates - the psychophysicist of the Stevens school would regard it rather as an experiment into perceived length.

There seems no way of experimentally distinguishing between the two possibilities, and of course the third possibility, that subjects are inaccurate in both perception and estimation, lurks somewhere in the background.

However, one thing is clear. All the mass of ratio estimations gathered by the new psychophysicists does show that when subjects are presented with physical stimuli from which to make ratio estimations of magnitude, be it length, distance, brightness, loudness, weight or whatever, the ratio estimates they make always fit the physical dimensions of the stimuli by a power function rather than indicating a linear relationship. The author suspects his hypothesis of distinguishable ratios elaborated in section 2 is akin to the mathematical arguments that Stevens uses to explain his power law (with the difference that it has "estimation" rather than "sensation" as the dependent variable). But whatever the cause, the implication is that when subjects are asked to estimate distance one should expect a power relationship between estimated distance and actual distance irrespective of cognition. The following maxim seems advisable: the relationship between estimated and physical distance should be treated as curvilinear unless it can be proved to be linear.

PART IV

THE SCOTTISH EXPERIMENT

1) REVIEW OF THE LITERATURE

(i) Urban Cognition

As previously mentioned, very little work has been done to study cognitive distance at a regional or national scale. However, there is a large body of literature dealing with cognition of distance at an urban, that is, intra-city rather than inter-city, scale. It therefore seems useful that we should briefly consider this work before proceeding further, to see if the results obtained by workers dealing with this particular scale of cognition might be helpful in formulating hypotheses at a higher scale of study.

Perhaps the easiest way of discussing the mass of different experiments is to take a thematic approach. Several hypotheses are common to more than one experimenter, and not all have produced confirmatory results. The first point to consider is a methodological one. Arguments in favour of different ways of collecting distance estimates have already been discussed; experimenters working at the urban scale have differed in the appoaches they have adopted. A graphical ratio scaling technique was employed by Lowrey (1970) and Ericksen (1975), whereas direct mileage estimates were sought by Lee (1970), Pocock (1972b) and Canter (1975). Zeller and Rivizzigno (1974) asked subjects to estimate the relative distance of all possible pairs in a matrix of locations on an arbitrary scale of zero to nine, an unusual procedure. McKay, Olshavsky and Sentell (1975) collected only ordinal data on the relative distances of supermarkets in Bloomington, Alabama. Some experimenters gathered data using more than one technique, including Briggs (1973a) and Golledge and Zannaras (1973). Notable is a study by Day (1975), in which he tested four different techniques in two

Sydney suburbs. The techniques were: measuring distance on a map drawn by the subject; verbal estimation; marking distances on a scale graduated in miles; and a ratio scaling technique using one scale base. The different techniques produced different results, which Day plotted graphically (Day, 1975, p.197).

Once again, the thorny problem of cognition and estimation rears its head. These four techniques may have yielded different results, but, though it is possible to determine which set of results most closely corresponds with the actual distances, it is not possible to tell which results most accurately reflect the subject's own cognitive distances. The situation is something as follows: it is impossible to tell which is the most accurate estimation technique until we have absolute figures for cognitive distances; but we cannot obtain absolute figures for cognitive distances unil we possess a perfect estimation technique. The only realistic solution would seem to be to take the most expedient way out of the dilemma according to individual circumstances. The more complicated techniques are only possible given a captive community of subjects, i.e. students. In dealing with "ordinary people" it is probably more appropriate to use a more familiar process such as mileage estimation (Canter and Tagg, 1975). Since subjects are more familiar with concepts of the order of five miles than they are with 5,000 miles, the objections to working with mileage estimates at a global scale are much less relevant here. As Canter points out (Canter, 1975, p7), distance estimation is a tiresome business for the ordinary subject, and as boredom increases, the care taken over each estimation decreases, something found even with Zeller and Rivizzigno's "captive" students. (Zeller and Rivizzigno, 1974). Keeping questionnaires simple would therefore seem advantageous in securing reasonably valid estimations.

Some of the work that has been done involving estimation of urban distance has been more concerned with using this as a tool in the investigation of the cognition of urban structure rather than the study of cognitive distance per se, and obviously this sort of study (including Pocock, Golledge and Zannaras among others) is less relevant to this thesis. Often the distance estimates obtained are processed by multi-dimensional scaling programmes in order to produce a distance-derived mental map of the city (the debt to Lynch, 1960) is acknowledged). There is obviously little to be gained here from discussing the results of these studies at any length. The results tend to be in terms of the overall measure of location error or "stress", which Zeller and Rivizzigno attempted to relate to length of residence, amd McKay, Olshavsky and Sentell attempted to relate to a variety of socio-economic factors.

Turning to two themes already discussed in part III, we find confirmation of the hypothesis that the relationship between estimated and actual distance is a non-linear one. This is found by both Ericksen and Briggs, although Lowrey produced results in which subjects' estimates most closely reflected Euclidean straight-line distances. Canter and Tagg found that a logarithmic regression tended to account for more variation than a linear one, but this was not consistent from subject group to subject group.

The distribution of distance estimations (as was seen in part III) can exhibit not only considerable spread, but considerable skew as well. Day makes the important point that

"the previously standard use of mean values is misleading as it gives a false impression of the extent to which a sample population holds the same image in common." (Day, 1976, p.198)

As Zeller and Rivizzigno found, mean figures tend to be more accurate than any of the individual subjects' figures. Canter also mentions the wide variation in individual responses (Canter, 1975,

p. 8).

Another problem that arises is the question of whether subjects should be asked to estimate "crow-flight" distances or walking distances, and though this matter has aroused some dispute, with different experimenters adopting different approaches, no conclusion seems to have been reached. It is possible that if one specifies direct distances are to be estimated, the complexity of route distance may still influence the results by causing overestimation in certain cases. It is equally possible that if one asks for travel distances to be estimated, straight-line proximity might influence the results in the opposite manner, by causing occasional underestimation of distance. And, once again, we are confronted by a variation of the black box problem; we cannot really tell which sort of distance is most appropriate to the subjects' own cognitions.

The themes most frequently covered in the literature with respect to interpreting variations in cognitive distance are those of direction (towards or away from the city centre) and straightness or crookedness of route; familiarity is also mentioned by several writers.

Turning to direction first, the issue lies between those researchers who found that subjects are relatively more prone to overestimating distances away from the city centre, and those who found the reverse to be true. Of the former, Lee explained his results in Dundee as perhaps due to the more attractive nature of the city centre to the respondents (Lee, 1970). However, American researchers, for example Briggs in Columbus, Ohio, found overestimation towards the city centre (Briggs, 1973a). The discrepancy is explained on the basis that, firstly, American city centres are less attractive than Dundee, and secondly, that the overestimation towards the centre is the result of the denser packing of perceptual events, i.e. that distance is being perceived in terms of events or matter.

Further light has been shed on the subject by Canter, who discovered, in a London-based experiment, that the direction of overestimation relative to the city centre appeared to be a function of the distance from the city centre of the respondent. The direction of overestimation was outwards for those living less than six miles from the centre; but inwards for those living further away. (Canter, 1975, p.188)

An attempted hypothesis also connected with space perceived in terms of events is that distances involving straight routes should be perceived as shorter than those involving corners. According to Lee, this has been shown to hold in the estimation of lines presented to the subject (Lee,1969). Briggs suggests that in the case of actual distances, the matter is complicated by the influence of crow-flight distance between the two points connected by a crooked route. Pocock produced a small experiment in Dundee, which, while not conclusive, did suggest the hypothesis to be worthy of further attention (Pocock, 1972a).

Another experiment worthy of mention was conducted by Brown, and was one of those mentioned in which the aim was to construct a "map" of a city from estimated interdistances. In the results it was found that the distance between two particularly remote points was consistently and dramatically underestimated, and it was suggested that the cause of this was that the subjects were insufficently aware of what lay between the two points (Brown, 1974).

The concept of "valence", stemming ultimately from Lewin (e.g. Stea, 1973a, Canter, 1975) has been drawn on by several workers as something to which distance estimation might be related. The idea is roughly that each individual has "life space" made up of places with which he is involved in various ways, either by interaction or by attitude. From this, familiarity with a place and attractiveness or unattractiveness are taken to be possible variations affecting the cognition of distance. We have already seen attractiveness drawn upon by Lee as a possible explanation of the relative underestimation of distances towards the centre of Dundee. A paper by Watson (1972) on mental distances in Hamilton, Ontario, takes the approach (on introspective grounds) that the social status of an area is fundamental to the way in which distances to places in that area will be perceived. The frequency of social trips is seen as an important variable in determining the "social distances" separating places, and this idea can be related to Lewin's "life space". Areas of similar social standing that were much visited could be characterised as more attractive and more familiar relative to unvisited and poorer districts.

David Canter devised a specific test of both elements of the hypothesis which he carried out in London; he regarded the results as a strong refutation of the valence hypothesis in both its forms - neither familiarity nor attractiveness had any discernable significance.

However, Day concluded that familiarity did have some effect at the urban scale, since he found that familiarity with a location tended to produce greater accuracy of estimation, while unfamiliarity led to overestimation. Ericksen, on the other hand, working in Kingston, Ontario, found that familiarity had no effect on the degree of misestimation, whereas attractiveness did - only more attractive places were seen as relatively more distant! Golledge and Zannaras, though, support Day's conclusions that unfamiliar places are seen as relatively further away than familiar ones.

A study by Gunter Meyer (1977) on the estimation of the length of shopping streets in the CBD concluded that familiarity was very much responsible for underestimation, and that attractiveness also tended to be associated with underestimation. By contrast, such factors as subjects' age, education and social class had no effect on distance cognition.

Canter, in what one must acknowledge to be the most thorough investigation of cognitive distance at any scale to date, also made some more tests worthy of mention. An experiment based on the estimation of travel time and distance along the London Underground, taking advantage of the fact that travel time along such a route is far more constant (and therefore objective) than ordinary motor routes, produced figures which demonstrated that distance estimates were not being based on time. This is the best evidence we have so far on the relationship between time and distance in the evolution of cognitive distance. Canter suggests that time estimations are derived from distance estimations rather than vice versa. (Canter, 1975, p. 11)

A test to see if the Thames acted as a barrier found that distances parallel to the river on the North side were estimated more accurately than those across the river - but distances on the South side of the river were not estimated significantly differently from either. In Canter and Tagg we find the suggestion that, at the scale of cities, roads, railways and rivers, rather than acting as barriers, may serve as conceptual links.

Investigation of transport modes showed that those who used buses produced consistently more overestimation of distances than those who travelled mainly by underground railway. The suggestion behind this would appear to be that the greater number of perceptual events experienced by the bus passenger is causing the relative overestimation. Further results from a study involving distance estimation within London by people living near Guildford supported this hypothesis that more detailed experiences make places seem larger.

The studies of cognitive distance at a regional scale are few: an unpublished experiment by Irene Buckman, one by Hansen, also unpublished, and a paper by Martin Cadwallader (1973). (Buckman and Hansen are both cited in Stea 1969a.) The first of these involved students in Providence, Rhode Island, estimating the distances of all possible pairings of six New England cities, plus New York, after having arranged them in order of increasing attractiveness. Information on familiarity was also obtained. The results were that 59% of the "trips" between two cities yielded shorter distance estimates in the direction of the preferred city. The significance of this figure was not tested but does not appear to be sufficent to count as a positive result. The effect of familiarity was apparently one of increasing accuracy with increasing familiarity, in line with at least half of Day's findings.

Hansen's study was carried out in San Cristobal la Casas (Mexico); students were asked to estimate the distance to Tuxtla Gutierrez and Comitan. The two distances are in fact identical in length, but the former city is separated from San Cristobal by a tortuous mountain road, while the route to Comitan is straighter and flatter. It was therefore hypothesised that the more tortuous distance would appear to be the longer of the two. The reverse effect occured; two-thirds of the 66 students estimated the straighter distance as the longer one. Stea (1969a) suggests that the distance to Comitan is perhaps more boring to bus passengers (the majority of the subjects travelled by bus) and therefore seems longer for that reason. Bus drivers, who actually had to negotiate the difficult road, might have given different answers.

Cadwallader completed his experiment on the Western American seaboard, in the vicinity of Los Angeles. Data were collected from ordinary households, subjects being asked to estimate distances to 30 cities in the Los Angeles basin. (However, the maximum distance was only 65 miles.) Estimates were collected using both mileage estimates and ratio scaling techniques. As with Day's findings, these two techniques yielded differing results, without it being possible to conclude that one technique was actually better than the other. And also as with Day, aggregate figures (i.e. means) were found to be misleading in suggesting a stronger relationship between cognised and actual distance than could be found at an individual level.

Amongst Cadwallader's further findings was the conclusion that distributions of distance estimations for particular cities tended to be positively skewed. This is in accordance with the author's findings; it seems logical that there should be wider scope for overestimation than for underestimation, since the range for underestimation is bounded by the area around the subject with which he is most familiar, and in which misestimations are unlikely to fall. Or, to put it more simply, that there is a necessary lower limit to underestimation, but no upper limit to overestimation. Neither at an aggregate nor at an individual level was there any evidence that a curvilinear model would fit the distance estimates any better than a straight linear one.

Turning to the valence hypothesis, no relationship between familiarity and distance estimation was found, nor could any relationship between perceived distance and attractiveness be discovered. (In the latter case, no correlation coefficient exceeded 0.2 .) Length of residence in the Los Angeles metropolitan area was also used as a variable, and again, it appeared to play no part in influencing distance estimations.

Overall, then, the preceding results show a number of things. Opinion is divided on the logarithmic/linear nature of cognitive distance. Distance perceived in terms of events still looks like an admissable hypothesis, but needs further verification. Distance perceived in terms of time is little tested, but appears to be of no significance. The effect of familiarity is under dispute, but the attractiveness of a place seems not to explain error in estimating distance towards it.

Finally, it is agreed that different methods of collecting data yield different results, but not in such a way that one method can be preferred to another. Also, owing to the spread and skew of distributions of distance estimations, the aggregating of such data into single means provides an unreliable indicator of cognitive distances at an individual level.

This last is of importance to the geographer, who is accustomed to dealing with populations rather than individuals. Individual images tend to be the domain of the psychologist, and cannot easily be viewed as significant or useful in geographical analysis. However, the problem is easily overcome by essentially the same procedure as was adopted in part III. The unreliability lies in the analysis of data subsequent to aggregation, that is, the examination of single means obtained from an amalgamation of unprocessed estimations, which may vary widely. Rather than this, it is important to analyse the data at the individual level, where each subject can be dealt with on his own terms, and then aggregate the findings, to see if any trends in the results are consistent from subject to subject.

2) EXPERIMENTAL DESIGN

In designing the second major experiment, a number of general as well as particular aims were held in view. The general aims were these.

(i) To conduct an investigation of cognitive distance in which the distances involved are inter-city distances within a significant region, and encompassing most of that region.

(ii) To conduct the investigation in such a way as to have as many focal points as possible, rather than just one.

(iii) To use "ordinary people" as subjects, rather than university students.

The region selected was Scotland, including the various islands to West and North of the Mainland. Within this area, nine towns and cities were selected; to these were added one town just outside the Scottish border (Berwick on Tweed) and one city in N.E. England (Newcastle upon Tyne) thus giving eleven centres in all. The original intention was to conduct questionnaire surveys in each of these centres in which people would be asked to estimate distances to each of the other centres. As will be mentioned later, one centre had to be dropped, leaving ten in all remaining.

While previous studies have produced matrices of estimated distances for all possible pairings of a certain number of places, this has always involved one set of subjects having to estimate all the interdistances, thus invoking the problems with regard to the estimation of remote distances already discussed. On this occasion it was desired that a matrix of estimated distances should be produced in which all the estimations should be made by people at the point in question.

With regard to choice of subjects, the following procedure was evolved. The first point to consider is that owing to the overall nature of these experiments (i.e. that they are concerned with variations of estimated distance that are effected by place rather ? or a than personal characteristics) the scrupulous nature of the sampling methods used by sociological geographers is not important. The experiment is so designed that any variation attributable to socio-economic factors will appear chiefly as background "noise", and can be eliminated as such, since the techniques used in the data analysis are specifically designed to analyse variation by place rather than variation by person. What was most desired was a reasonably mixed population of men and women who could easily be approached with regard to filling in questionnaires, and who would be relatively comparable from town to town. Practical factors were extremely important, and it was necessary to find some environment in which the subject would be able to co-operate relatively free from work or domestic constraints. Taking these factors into consideration, it was decided that the best population to sample would be that provided by the community of public library users.

The procedure was as follows: the library authorities in each town were contacted, and the project explained. Advice was then taken on the selection of a local library to be used in the experiment. If there were no local libraries in the particular town, the main library was used. The priorities in the selection of library were, in order of importance:

(a) library serves a varied population;

(b) library is reasonably busy;

(c) library is reasonably well-provided with tables and chairs.

Advice was also sought on the particular library's busiest periods; these were usually Friday evening and Saturday morning, which were also the times when the population of library users was most varied, and so the questionnaire surveys were generally undertaken at weekends.

The questionnaires were distributed by the author to users entering the library, who were asked to fill in the questionnaire on their own, and to hand it in to the library issue desk before they left. One hundred questionnaires were distributed at each library. The only variation from the procedure was in Stornoway, where the library offered to distribute the questionnaires themselves.

The towns selected were as follows: Aberdeen, Ayr, Berwick on Tweed, Dundee, Edinburgh, Glasgow, Inverness, Lerwick, Newcastle on Tyne, Stirling and Stornoway. However, Glasgow City Libraries refused to co-operate, even after intercession on the author's behalf by Edinburgh City Libraries. Since by this time an ample amount of data had already been collected, and since to adopt some other approach would lay the experiment open to the charge of inconsistency, Glasgow was dropped from the eleven centres. However, the data on the estimation of distance to Glasgow from the other centres were retained.

With regard to questionnaire design, the following points were carefully considered.

(a) It should be as simple as possible for the subject to understand. This more or less necessitated asking for distance estimates to be given in miles.

(b) It should be kept reasonable short, particularly with regard to impersonal questions (i.e. estimation of distance and time) which would be considered boring by the respondent.

The particular aims of the experiment were as follows:

(i) to test the commutativity of cognitive distance;

(ii) to see if measurements of cognitive error can be explained in terms of admitted ignorance on the part of the subject;

(iii) to test the linearity or non-linearity of cognitive distance at this scale;

(iv) to look for consistencies of under- or over-estimation of distance to a particular place or between two particular places, and to attempt to explain these;

(v) to look for evidence of cognitive barriers;

(vi) to test for a connection between perception of distance and perception of time;

(vii) to test the "valence" hypothesis by examining the relationship between cognitive distance and estimated familiarity and attractiveness.

The questionnaire was designed with these points in mind. An example of a questionnaire is included in the appendix. Each contained the following questions, each of which was to be answered for each of ten places (presented in alphabetical order).

Question 1: subjects were asked to estimate distances in miles. The nature of the distance (whether direct or road) was left up to the subject.

Question 2: subjects were asked to estimate the accuracy of their answers to Question 1 by using a five-point scale.

Question 3: subjects were asked to indicate the mode of transport they would employ in travelling to each place, assuming the most likely circumstances for their travelling.

Question 4: subjects were asked to estimate (in hours) how long it would take them to travel each journey.

Question 5: subjects were asked to estimate (using a five-point scale again) how attractive they found each place (a) to visit (b) to live in, assuming employment, etc, to be no problem.

Question 6: again using a five-point scale, subjects were asked to estimate their familiarity with each place. A "1" indicated they had never visited the place, while a "5" showed they had lived there.

Other questions: various bits of personal information were collected for the sake of completeness. These included sex, occupation, birthplace and length of residence.

3) DATA ANALYSIS

The strategy employed in the analysis of the data was similar to that used in part III. Descriptive statistics of each population of data were obtained via the SPSS Frequencies programme, and then the data for each subject were processed individually using regression analysis, for which original programmes were written by the author.

Four sets of actual distances between all the various places were obtained: road distances were provided by the Automobile Association (with the marine parts of the journeys supplied by P&O Ferries and by Caledonian McBrayne); rail distances were obtained from British Rail; straight line distances were measured on a typical atlas map (conical projection; Reader's Digest, 1961), and precise great circle distances were calculated trigonometrically.

(i) Frequencies

The SPSS Frequencies programme was used to obtain descriptive statistics for the distance estimates, familiarity, confidence and attractiveness data. Table 4.1 shows the results for the distance estimates; both mean and median figures are given (rounded to the nearest mile) to illustrate the degree of skew, which is variable. where the two figures are similar, skew is low; where the median is less than the mean, skew is positive. Also given for comparison is the actual road distance.

The skew is not highly revealing in itself. An instance such as the Dundee to Berwick cell where the mean is accurate but the median is lower, indicates that a large number of small underestimations are being evened out by a few large overestimations.

As can be seen, many of the figures are very accurate.

Table 4.1

MEAN ESTIMATED
MEDIAN ESTIMATED
AND ACTUAL ROAD DISTANCES

from | to	Aber	Ayr	Berw	Dund	Edin	Inve	Lerw	Newc	Stir	Stor
Aberdeen		168 170 186	191 190 184	73 70 67	127 125 127	104 104 105	269 250 193	250 240 236	107 100 117	230 220 217
Ayr	165 171 186		105 99 133	107 100 123	73 77 75	154 151 215	269 271 379	150 136 158	64 64 70	194 200 327
Berwick	186 182 184	116 101 133		118 116 114	59 58 57	205 200 216	344 333 377	63 63 63	91 86 88	279 297 328
Dundee	69 68 67	114 110 123	114 105 114		60 60 58	126 117 131	259 250 260	183 160 166	55 52 54	199 191 243
Edinburgh	145 140 127	85 80 75	69 70 57	61 53 58		156 141 159	315 299 320	130 120 109	43 38 36	236 220 271
Inverness	104 104 105	202 200 215	226 220 216	140 140 131	167 160 159		230 212 298	288 280 268	142 140 146	148 136 112
Lerwick	190 180 193	329 311 379	368 350 377	259 250 166	310 300 320	193 181 298		441 404 429	291 280 310	290 252 410
Newcastle	238 221 236	148 141 158	68 64 63	160 149 166	119 110 109	256 250 268	386 378 429		173 142 145	341 300 380
Stirling	117 115 117	65 60 70	104 98 88	63 54 54	41 35 36	141 140 146	298 281 310	162 150 145		236 201 258
Stornoway	197 199 217	286 261 327	370 369 328	230 243 227	288 278 271	119 100 112	213 205 410	413 398 380	247 231 258	

In each cell upper figure is mean estimated distance
middle figure is median estimated distance
lower figure is actual road distance
(all figures in miles)

Sometimes this is reasonably predictable - one might, for instance, expect the residents of Berwick to be well informed on the distance to Newcastle. However, one would not expect them to be so accurate on the subject of the distance to Aberdeen. But again it must be recalled that these are aggregate figures, and no indication of the number of people within each sample that gave accurate answers. They do not indicate the strength of an accurate image, but merely show that the inaccuracies present have tended to even themselves out.

It is interesting to note that these figures more closely resemble road distance than direct distance. It will be recalled that the precise form of distance was not specified to the subject so that he could indicate his own preference. The notable exception, not surprisingly, is the distance between Stornoway and Lerwick, which is almost entirely sea. The direct distance is 199 miles, and thus the Stornoway figures are only slightly out. The Lerwick figures are closer to the direct distance than the road distance (via Aberdeen and Ullapool) but contain a sizeable overestimation. The direct distance is also suggested by a few other figures (Lerwick to Inverness, which has a direct air connection, is one), whereas some fall between the two in such a way that it is impossible to tell if one is overestimated or the other is underestimated. Dundee to Stornoway is an example of this: the direct distance is 150 miles, the road distance 243 miles, and the mean and median, 199 and 191 respectively, could refer to either (or both).

To clarify the results shown in table 4.1, table 4.2 has been prepared. In this, where the mean estimated distance has been greater than the actual road distance by more than two standard errors, a plus records this overestimation; a minus indicates the mean estimate to be more than two standard errors less than the correct figure. (Only road distances have been considered, hence the

Table 4.2

OVERESTIMATION AND UNDERESTIMATION

from | to	Aber	Ayr	Berw	Dund	Edin	Inve	Lerw	Newc	Stir	Stor
Aberdeen		-			A	A	+		-	
Ayr	-		-	-		-	-		-	-
Berwick	A	-					-	A		-
Dundee		-	A			A	A			-
Edinburgh	+	+	+			A	A	+	+	-
Inverness	A	-		+	+		-	+		+
Lerwick	A	-		A		-				-
Newcastle	A		+		+		-		+	-
Stirling	A		+					+		
Stornoway		-					-			

See text for key.

minuses in the two Stornoway/Lerwick cells.) Where the mean estimate is within half of one standard error of the correct mileage, an "A" (for accurate) is recorded. To a certain extent these parameters are arbitrary, but fairly helpful. In examining table 4.2 it should be borne in mind that rows across represent images centred from each particular town; columns down show the images of that town as estimated by the others. Both Stornoway and Lerwick appear to be viewed as too close; some of this may be due to the straight-line distance influencing the results. However, a notable curiosity is the plethora of underestimations associated with Ayr - both to and from the town. Interestingly, the only town to overestimate the distance to Lerwick was Aberdeen, Lerwick's main link with Scotland. That this distance was accurately perceived by the Shetlanders is scarcely surprising, as it is a matter of some concern to the islanders.

The sample most prone to overestimation was that of Edinburgh. While it would be interesting to postulate some sort of gravity model, that distances down the urban hierarchy are overestimated, the results for Newcastle do not outstandingly confirm this, nor do those for Aberdeen.

What is notable about the Aberdeen figures is the extent to which the distance to Aberdeen tends to be accurately estimated. This should not be taken as evidence that Aberdeen generates a lot of information related to distances, but rather that the trends to overestimation and underestimation exactly balance one another out.

The most overestimated distances to any place are the distances to Berwick and Newcastle, with three plusses each. This might suggest the effect of the Anglo-Scottish border, but it should be pointed out that one of the Berwick plusses is from Newcastle!

A test of commutativity was made as follows: mean distance estimates for each link in each direction were compared, and where there was no overlap between one mean estimate plus or minus two standard errors and the other one plus or minus two standard errors, the two mean estimates were deemed to be significantly different. (Note that this is really a test for non-commutativity.) Those links that were considered to be non-commutative - nine out of a possible total of 45 - are marked on figure 4.3 . Two things are notable; firstly, the longer distances tend to be the non-commutative ones. This may be partly due to the test employed - the longer the distance the more room for significant discrepancies, notwithstanding the standardising effect of using standard error as a parameter. Secondly, all but one of the nine links cross either sea or the Anglo-Scottish border. This might suggest that marine or political barriers may have non-commutative effects, but it should be remembered that the longest distances tend to be those crossing the sea and the border simply because of the geometry of the chosen points.

Table 4.4 shows the mean confidence or certainty expressed in the distance estimates. The maximum possible value is 5.00, the minimum possible 1.00 and the central point of the scale 3.00 . A rough division is therefore possible of results less than 3.00 indicating "on average unsure" and results over 3.00 indicating "on average confident". The figures are not particularly surprising. All the samples were unhappy about estimating distances across water, both to and from the islands. No figures greater than 3.00 appear in the Lerwick and Stornoway columns, and the only figures in the Lerwick and Stornoway rows to exceed average are those for Aberdeen, Edinburgh, and for Stornoway, Inverness. Much the same is true of distances across the Anglo-Scottish border. Whatever other effect perceptual barriers may have, it is quite clear that they make the

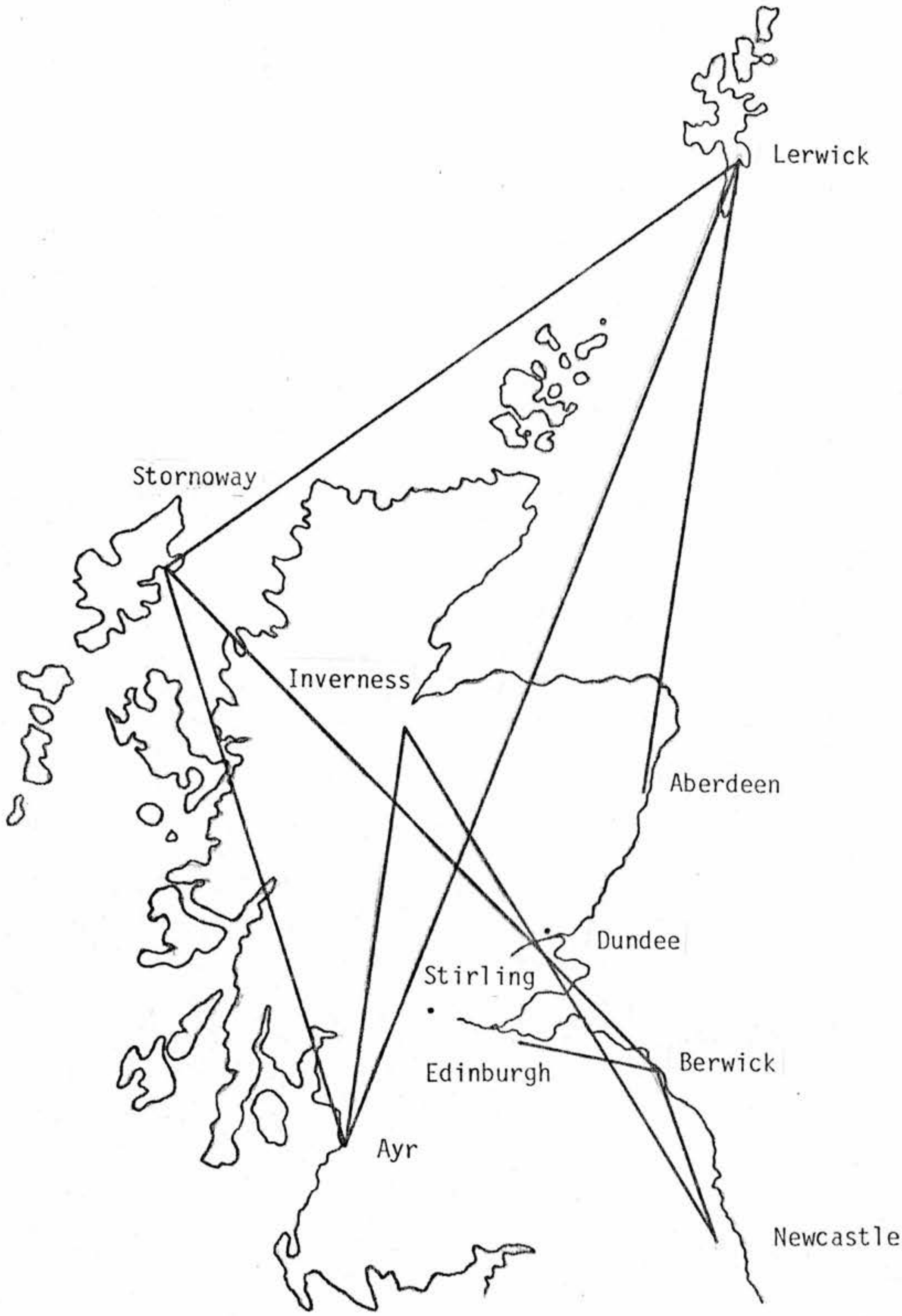


Figure 4.3

Non-commutative distances

Table 4.4

MEAN CONFIDENCE ESTIMATIONS

by | of	Aber	Ayr	Berw	Dund	Edin	Inve	Lerw	Newc	Stir	Stor
Aberdeen		3.18	3.04	4.13	4.33	4.44	2.11	2.64	3.52	1.98
Ayr	3.09		2.82	3.17	4.15	2.89	1.92	2.76	3.19	1.92
Berwick	2.89	2.87		2.84	4.68	2.81	1.88	4.64	3.06	1.76
Dundee	4.19	3.40	2.75		4.07	3.36	1.97	2.80	3.59	1.95
Edinburgh	3.26	3.02	3.42	3.38		3.22	2.16	3.31	3.48	2.00
Inverness	4.34	3.04	2.72	3.25	3.92		2.28	2.59	3.40	2.49
Lerwick	3.97	2.45	2.27	2.97	3.06	2.73		2.30	2.37	1.84
Newcastle	2.96	3.97	2.86	3.78	3.37	1.94	2.61		1.75	1.32
Stirling	3.59	3.68	3.23	3.76	4.42	3.33	2.17	2.97		2.08
Stornoway	3.05	2.38	2.38	2.48	3.10	3.19	1.90	2.00	2.52	

Table 4.5

MEAN FAMILIARITY ESTIMATIONS

by | of	Aber	Ayr	Berw	Dund	Edin	Inve	Lerw	Newc	Stir	Stor
Aberdeen		2.24	1.76	3.02	3.67	3.07	1.37	1.98	2.61	1.30
Ayr	1.91		1.42	1.70	3.49	2.13	1.02	1.85	2.51	1.11
Berwick	1.85	1.97		1.78	3.90	2.18	1.20	3.91	2.24	1.12
Dundee	3.07	2.27	1.84		3.72	2.42	1.05	2.06	2.57	1.17
Edinburgh	2.31	2.13	2.29	2.33		2.35	1.24	2.24	2.55	1.11
Inverness	3.30	2.19	1.77	1.95	3.55		1.30	1.77	2.67	1.81
Lerwick	4.00	1.89	1.57	2.26	3.72	2.33		1.80	1.83	1.17
Newcastle	1.61	1.79	2.99	1.56	3.06	1.91	1.09		1.80	1.04
Stirling	2.70	2.72	1.88	2.44	3.77	2.56	1.30	1.95		1.27
Stornoway	2.43	1.67	1.14	1.81	2.75	2.95	1.00	1.24	1.86	

Table 4.6(a)

MEAN ATTRACTIVENESS TO LIVE

by | of	Aber	Ayr	Berw	Dund	Edin	Inve	Lerw	Newc	Stir	Stor
Aberdeen		3.54	3.36	2.07	3.96	3.28	2.60	2.18	3.24	2.56
Ayr	3.44		3.35	2.52	4.00	3.49	2.90	2.48	3.43	2.98
Berwick	3.39	3.59		2.71	4.00	3.72	3.12	2.40	3.29	3.16
Dundee	3.97	3.77	3.22		4.11	3.92	2.95	2.57	3.25	2.83
Edinburgh	3.60	3.22	3.20	2.22		3.16	2.69	2.38	3.12	2.42
Inverness	3.72	3.66	3.35	2.25	4.06		3.07	2.28	3.15	3.05
Lerwick	3.59	3.21	3.03	2.39	3.76	3.35		2.57	2.92	2.85
Newcastle	3.21	3.14	3.34	2.88	3.50	3.42	2.77		3.03	2.79
Stirling	3.72	4.00	3.41	2.48	3.89	3.67	3.33	2.30		3.13
Stornoway	3.65	3.25	3.15	2.55	3.63	3.15	2.75	2.30	3.00	

Table 4.6(b)

MEAN ATTRACTIVENESS TO VISIT

by | of	Aber	Ayr	Berw	Dund	Edin	Inve	Lerw	Newc	Stir	Stor
Aberdeen		3.98	3.65	2.33	4.51	3.80	3.43	2.25	3.58	3.46
Ayr	4.08		3.80	2.84	4.29	4.02	3.63	2.77	3.73	3.52
Berwick	3.90	3.98		3.02	4.60	4.08	3.92	3.07	3.85	3.95
Dundee	4.08	4.14	3.70		4.30	4.14	3.29	2.52	3.61	3.32
Edinburgh	3.92	3.69	3.49	2.41		3.70	3.52	2.55	3.49	3.56
Inverness	3.95	3.85	3.73	2.31	4.56		3.79	2.62	3.50	3.73
Lerwick	4.02	3.47	3.39	2.65	4.37	3.57		2.68	3.19	3.41
Newcastle	3.67	3.75	3.88	3.32	4.20	4.05	3.71		3.69	3.67
Stirling	4.21	4.21	3.62	2.64	4.40	3.98	4.00	2.69		3.92
Stornoway	4.00	3.38	3.33	3.00	4.40	3.71	3.29	2.71	3.29	

estimation task more difficult.

Short distances, not surprisingly, are cognised as being more accurately estimated, especially to large cities. Most of the figures in excess of 4.00 appear in the Edinburgh and Aberdeen columns.

Presumably it is fair to assume that uncertainty is likely to produce greater variation in results; in which case this could be taken as an explanation of at least some of the results of the commutativity test in figure 4.3 .

Tables 4.5 and 4.6 show the mean figures for familiarity and attractiveness, and are worked on the same system as 4.4 . Note that the minimum is actually touched in the Stornoway/Lerwick cell of table 4.5, showing that none of that sample had ever been to Lerwick. A general similarity between the pattern of table 4.5 and that of table 4.4 can be observed. Possible remarks on table 4.6 include noting that Aberdeen appears popular and also has an "accurate" image in table 4.2, which might fit in with the hypothesis that attractive places were more accurately located were it not that Edinburgh is even more popular, yet has fewer "A"s. (For that matter, the "A" results for Aberdeen and the highest figures in table 4.6 do not entirely co-incide.) Dundee and Newcastle are the most unpopular places.

However, there is a limit on what can be gained from visual inspection of this kind, and these tables are presented partly for the sake of completeness. The data will be analysed in greater depth later.

(ii) Which Distance?

Although the mean distance estimates come very close to the road distances most of the time, this says nothing about the pattern of distances estimated by each individual subject. The problem is essentially the same one as was encountered in part III when answering the question as to whether estimates conformed more closely to great circle or map distances, and the same logic can be applied to solve it. The questions that must be asked are these: do the estimates given by each subject conform more closely to road, map or great circle distances, and do the estimates approach more closely a linear or a logarithmic model? In order to answer these questions, the estimates given by each subject were regressed individually against road, map and great circle distances, and then the logarithms of the estimates were regressed against the three corresponding logarithmic standards. For each subject, the highest correlation coefficient of the six was recorded, and a mark awarded to the appropriate regression. Then, for each sample, the number of marks each regression had scored (the number of subjects in that sample favouring that regression) was totalled.

Table 4.7(a) shows the results; the figure in each cell is the number of subjects in that sample whose highest correlation coefficent was for that regression. Two things stand out in particular. The first is that road distances provide the best standard for all samples with the exception of Stornoway. This confirms the previous results of table 4.1 . Great circle distances came out only slightly better than map distances, and did rather poorly by comparison in Ayr, Stirling and Stornoway.

The second important point is that the logarithmic regressions appear to have consistently better support than the linear ones. Log road and log map regressions received twice as much support as their linear equivalents.

It was next decided to simplify the table by operating a sort of transferable vote system. The map standards were eliminated and the

Table 4.7(a)

COMPARATIVE REGRESSIONS

Number in each cell is no. of subjects with appropriate regression yielding highest value of r.

	Road	Log.Rd.	Map	Log.Map	Gt.C	Log.Gt.C	Total
Aberdeen	6	28		1	5	6	46
Ayr	12	16		15	3	1	54
Berwick	28	30		2	3	1	64
Dundee	12	35	2	4	13	4	70
Edinburgh	15	21	5	4	7	4	56
Inverness	7	43	9	4	5	16	84
Lerwick	12	17	4	7	11	13	64
Newcastle	22	26	4	3	5	10	70
Stirling	8	26	8	22		3	67
Stornoway		2	5	10	3	1	21
TOTAL	122	244	37	72	55	66	596
2nd TOTAL	366		109		121		

Table 4.7(b)

	Road	Log.Rd.	Gt.C	Log.Gt.C
Aberdeen	6	28	5	7
Ayr	13	18	4	19
Berwick	28	30	3	3
Dundee	14	35	13	8
Edinburgh	15	22	12	7
Inverness	8	45	13	18
Lerwick	12	17	15	20
Newcastle	22	26	9	13
Stirling	8	39	14	6
Stornoway		2	8	11
TOTAL	126	262	96	112
2nd TOTAL	388		208	

Total linear = 222
Total logarithmic = 374

experiment re-run. The result was table 4.7(b). We now find that, of the two standards, great circle distances are most appropriate with respect to the figures from Lerwick and Stornoway, while the other samples all relate better to road distances. The implication, that islanders are less likely to think in terms of road distances than mainlanders are, is scarcely surprising.

About two-thirds of all the subjects gave estimates conforming more to a logarithmic pattern. A look at the table also reveals that the road distance camp is much more logarithmic in nature than is the great circle camp. Those who think in great circle terms also seem to be more inclined to think in linear, i.e. non-logarithmic terms. All the same, in only three samples can cell pairs be found where the linear score exceeds the logarithmic - the small great circle contingents from Dundee, Edinburgh and Stirling.

The conclusions that were drawn from the aforegoing with respect to the further course of data analysis were as follows: firstly, that, as previously hypothesised, logarithmic standards tend to produce a better modelling of the distance estimates than do linear ones. Since in no samples did the "linear" subjects outnumber the "logarithmic" ones (though the Edinburgh sample was a close run) it seems justifiable to continue the practice adopted in part III and confine the further analysis to logarithmic regressions. However, despite the fact that the overall proportion of subjects favouring great circle regressions above road distance ones was no greater than the proportion of subjects favouring linear rather than logarithmic regressions, it was decided to retain the great circle standards. This was done for two reasons. Firstly, the distribution of road/great circle subjects was such that the latter were in the majority in two samples, Lerwick and Stornoway. Certainly in these samples, it would be unwise to discard any consideration of direct distances. Secondly, whereas the tendency to logarithmicity or linearity is a general one for each subject, distance standards can vary within the estimates given by each subject, as was shown in part III. This makes the dichotomy of road and great circle distances much less easily disposable than the linear/logarithmic one. In part III the technique we called "parallel regression" was developed to deal with the problem of map and great circle distances, and the same technique can be applied to the question of road and great circle distances in just the same way.

(iii) Overestimation and Underestimation

The next stage in the experimental procedure was to determine which distances in the survey were significantly overestimated or underestimated - these distances we will refer to as being misestimated. As previously outlined, a parallel regression technique was used in this analysis. The distance estimates for each subject were converted into logarithms (on the grounds that, as previously shown, a logarithmic model gave better results than a linear one) as were the standard distances for road and great circle routes. The individual subject's estimates were then regressed against both standards, and the residuals calculated for each place. Then, for each place, the lowest residual (in terms of absolute value) was selected. The lowest residuals naturally tended to come from the best regression, usually that with road distances. In such cases, when residuals were found to be lower on the great circle regression, although this usually seemed to indicate an estimation made with reference to great circle distances, this interpretation is not, theoretically speaking, invariably or necessarily true. The regression line takes into account the set of estimations as a whole, and is not simply related to any one estimation in isolation. When residuals were found to be lower on the great circle regression in cases where the lowest residual were mostly from the road regression, this was taken as an indication that the larger individual residual on the road regression could to some extent be explained away by providing a different overall perspective on the estimations as a whole. This perspective is the great circle regression. In those cases where large residuals could not be explained away in this manner, where large residuals were found to be present on both regressions, this was taken as strong evidence of a definite misestimation on the subject's part, quite independent of road or great circle interpretations of the data. For each particular distance, a list of appropriate residuals was drawn up to see whether the majority of these were negative or positive, negative results indicating underestimation and positive results overestimation. The significance of these results was assessed in two ways, firstly by a calculation of the probability of getting a similar majority on one side or the other by chance and secondly, as some sort of gauge as to the significance of the size of residuals involved, the mean residual was assessed to see if it lay more than two standard errors away from zero. The results of this are expressed as table 4.8 . In each cell, the left-hand symbol indicates misestimation significant at the 90% level or greater using binomial probabilities, and the right hand symbol indicates that the mean residual was more than two standard errors away from zero. The plus symbol indicates positive residuals and overestimation; the minus symbol indicates negative residuals and underestimation.

Comparing table 4.2 with 4.8, it will be seen that the latter has more profuse detail, and is generally more informative, especially since it takes into account logarithmicity, variations in the cognitive mile, and so on. The only advantage of 4.2 is that it

Table 4.8

SIGNIFICANT MISESTIMATIONS

	Aber	Ayr	Berw	Dund	Edin	Glas	Inve	Lerw	Newc	Stir	Stor
Aberdeen		- -				-			+ +	- -	
Ayr	+ +				+ +	- -		- -	+ +		-
Berwick	+ +	- -		+ +	- -	- -	+ +		- -	-	-
Dundee		-	+ +			-			+ +	- -	-
Edinburgh	+ +		+	+ +		- -		- -	+ +		- -
Inverness	- -	+	+ +	+ +	+	+		- -	+ +		
Lerwick		- -	+ +	+ +	+	-	- -		+ +		
Newcastle	+ +	- -	- -				+ +	-		+	-
Stirling	+	- -	+	+ +	- -	-	+ +	- -			
Stornoway			+ +		+ +		-	- -	+ +	+	

First symbol shows misestimation significant by frequency
Second symbol shows misestimation significant by size

+ indicates overestimation
- indicates underestimation

records when mean distances happen to co-incide with actual figures; but, as already discussed, this is not all that significant in itself. The two tables have several features in common, but these are better developed in the second one. Highly prominent is what appears to be the effect of the Anglo-Scottish border: distances to Newcastle and Berwick both tend strongly to be overestimated; only the interdistance between the two is underestimated. However, there is a similar, though less marked, tendency for distances to Aberdeen and Dundee also to be overestimated. The distance to Aberdeen is only underestimated by its close neighbour, Inverness. The places to which distances tend to be underestimated are Lerwick, Ayr and Glasgow, and, to a certain extent, Stornoway. Many of these results do not consistently fit simple hypotheses. An attempt to explain underestimation towards Glasgow with reference to its place in the urban hierarchy would have to account for the absence of similar effect vis a vis Edinburgh. However, one useful start will be to seperate distances that are equally misestimated from either end, that is, that are cognitively commutative. Table 4.9 has been compiled by comparing the left-hand components of the cells of table 4.8; where cells are symmetrical across the diagonal with respect to these components a "1" is recorded in the corresponding cells of the "commutativity matix". This "1" indicates the distance in question to be either significantly overestimated in both directions, significantly underestimated in both directions, or significantly misestimated in neither direction, significance being assessed by consistency of direction of residual. Using this rather more stringent test of commutativity than was employed in devising figure 4.3, we find that only about one-third of all the distances are cognitively commutative. These are mapped as figure 4.10 (a) and (b). Ironically, 4.10(a), showing commutative distances, is at least

Table 4.9

COMMUTATIVITY MATRIX

	Aber	Ayr	Berw	Dund	Edin	Inve	Lerw	Newc	Stir	Stor
Aberdeen		0	0	1	0	0	1	1	0	1
Ayr	0		0	0	0	0	1	0	0	1
Berwick	0	0		1	0	1	0	1	0	0
Dundee	1	0	1		0	0	0	0	0	1
Edinburgh	0	0	0	0		0	0	0	0	0
Inverness	0	0	1	0	0		1	1	0	1
Lerwick	1	1	0	0	0	1		0	0	0
Newcastle	1	0	1	0	0	1	0		1	0
Stirling	0	0	0	0	0	0	0	1		0
Stornoway	1	1	0	1	0	1	0	0	0	

0 = Non-commutative estimations
1 = Commutative estimations
(Based on frequency results only)

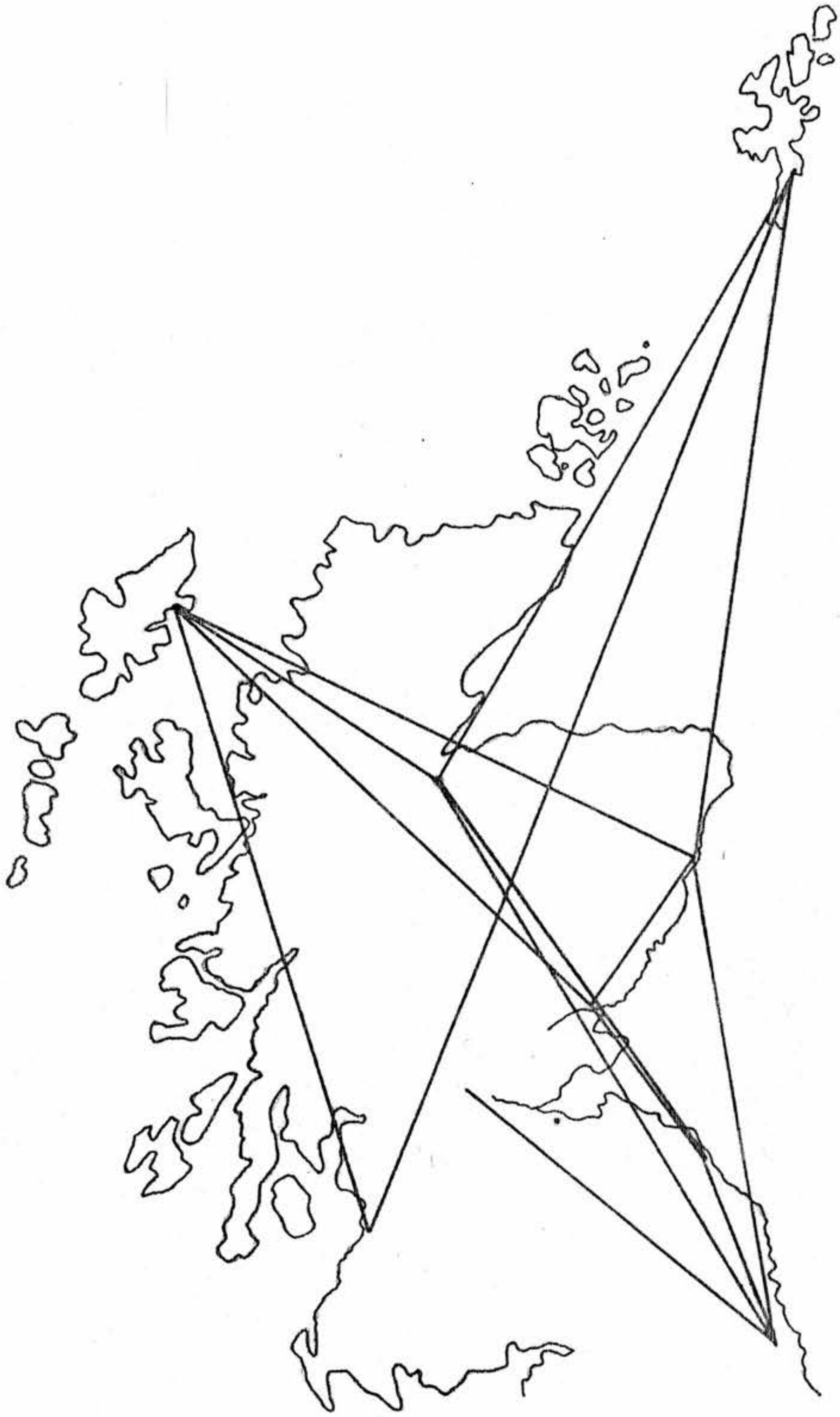


Figure 4.10(a)

Commutative distances

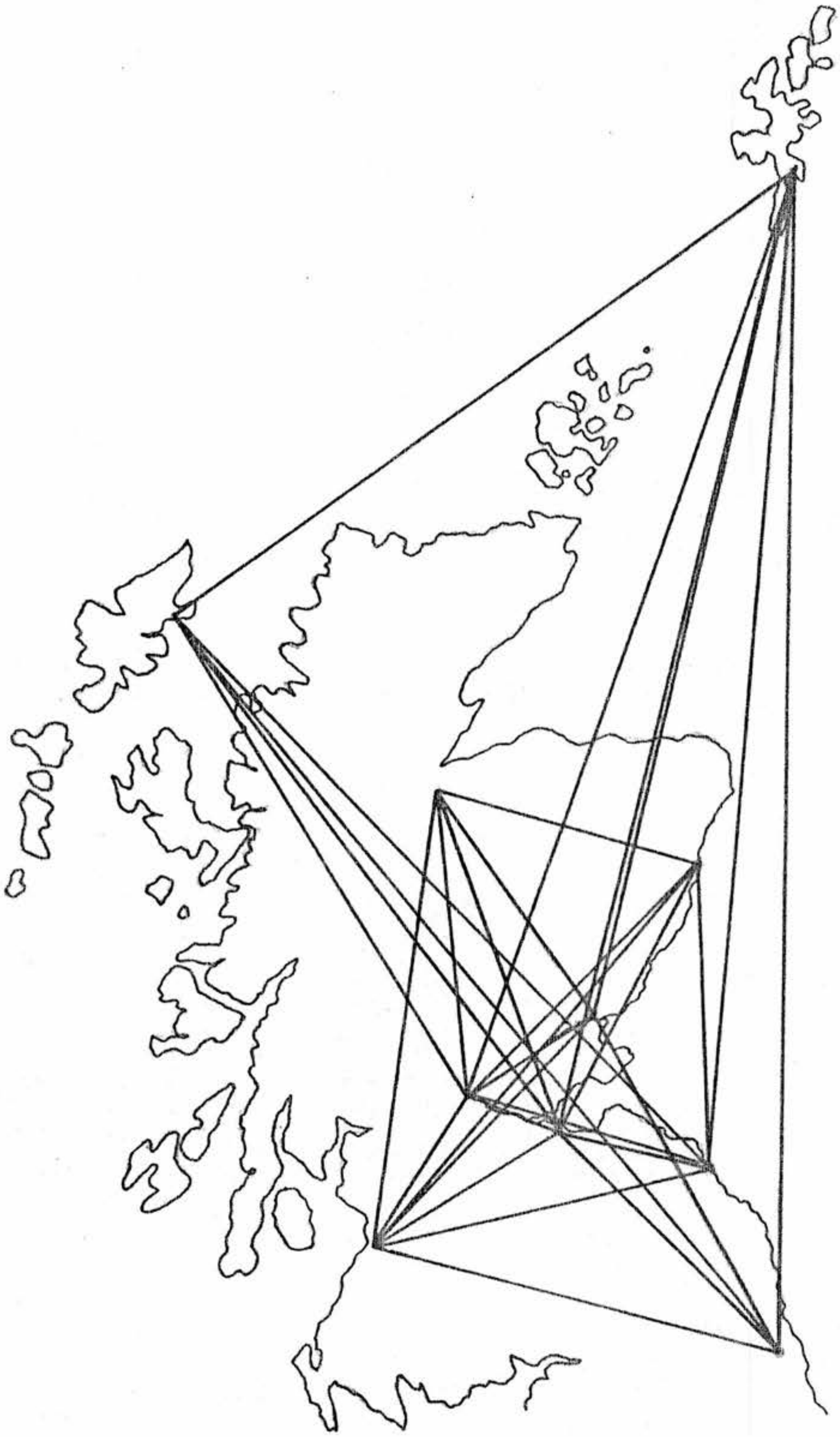


Figure 4.10(b)

Non-commutative distances

superficially similar to 4.3, showing non-commutative distances! This illustrates the dangers of using mean figures as though they represented the population consistently. Figure 4.10 should be regarded as the more authoritative version.

There is no obvious pattern in the results, although it will be noted that there is a particular lack of commutativity where the Scottish lowlands are concerned - of the routes marked in figure 4.10(a), only two involve Ayr, one involves Stirling, and none involve Edinburgh. (Note that Glasgow is not featured since only estimates of distance to Glasgow were available.) It is difficult to tell if this reflects some sort of "core" effect, but if it did, one would expect Dundee to have at least as few commutative links as Ayr, rather than as many as Lerwick. With only fourteen commutative links to go round, it is difficult to tell to what extent the end pattern is merely a product of chance. Of these fourteen links, four were overestimations, four were underestimations, and six were neither. This is no help in suggesting ways of predicting which distances are likely to be commutative.

The two suggestions that do arise are firstly, that given the high degree of non-commutativity, attributes of the end-points of the routes may be significant; secondly, for the same reason, barriers that do appear may not necessarily have the same effect when traversed in either direction.

(iv) Regression Gradients

The next step in the analysis was to examine the characteristics of the regression gradients produced by each sample. For each subject the regression with the highest correlation coefficent (of the two logarithmic regressions used earlier) was selected and the regression gradient recorded. The population statistics were then assessed for each sample.

The results were very consistent. Distributions usually had a mean of about 0.9 , with a maximum value of 0.99 (never as much as 1.0) and a minimum value of 0.5 , occasionally lower. The distributions were therefore negatively skewed and highly peaked. One subject (from Stirling) in the whole experiment produced a negative gradient. A summary of the figures is presented as table 4.11.

These results are very promising. They do seem to indicate a remarkable consistency up and down the country, and suggest that in terms of general distance estimation the relationship

$$\log ED = 0.9 \log AD + c$$

where ED is estimated distance and AD is actual distance provides a reasonably reliable portrayal at this scale of distances. (The constant c was invariably small, with typical values of + 1.0, or less.) The lack of any gradients of value 1.0 or greater is also very interesting, and certainly suggests that the cognitive mile is almost invariably greater than a real mile. Certainly the consistency of these results is much greater than was expected, and also considerably greater than the corresponding results in part III, at least with regard to consistency within each sample. This is perhaps due to the greater familiarity that subjects would have with the mile as a unit of distance than they would with a much larger unit (the Edinburgh London distance, or its equivalent in miles).

However, though the above may deal with the general pattern of distance estimations, it is still necessary to further pursue the individual aberrations discussed in section (iii) with a view to explanation.

(v) Place Characteristics

It now becomes appropriate to turn to the various elements that make up the loosely-termed "valence" hypotheses. This is ultimately a question of assessing the extent to which it can be said that variations in distance estimation are explicable by considering perceived attributes of the place to which the distance is estimated. These perceived attributes boil down to familiarity (in terms of experience) and desirability, or attractiveness. This latter, it will be recalled, was subdivided in the questionnaire into attractiveness to live (ATL) and attractiveness to visit (ATV). This also seems an appropriate place to consider another semi-psychological attribute, this one referring to the distance itself - the subject's confidence in his or her ability to estimate the particular distance.

The following hypotheses were proposed: (a) accuracy of estimation is proportional to estimated confidence; (b) accuracy of estimation is proportional to estimated familiarity; (c) distances to places perceived as being more attractive are also more accurately estimated; (d) more familiar places will tend to be estimated as being closer, if anything, than less familiar ones; (e) similarly, distances to more attractive places will tend to be underestimated.

The two different types of attractiveness yield hypotheses (c1) and (c2), and also (e1) and (e2). Hypotheses (b) and (d), and (c) and (e) should not be taken as being contradictory. The idea is rather that a familiar place will tend to be more accurately located, but if misplaced, it will tend to fall on the near side, and unfamiliar places will tend to be located less accurately and further away (this is suggested by Day).

The technique used in this analysis was quite simple. For each subject, two sets of residuals representing misestimation were obtained: the set already used in section (iii) from parallel regression, and the absolute values of these (i.e. all the signs were eliminated from the residuals in producing the second set, while the magnitudes remained unaltered). The first of these two sets was taken, as before, to represent over- and underestimation on the part of each subject; the larger the positive value, the more overestimation, the larger the negative value the more underestimation. The second set was regarded as simply representing the degree of inaccuracy. The larger the modulus residual, the more the estimation deviated from its "correct" position on the regression line. To test the hypotheses relating to level of accuracy only, that is, (a), (b) and (c), the second set of residuals was correlated with the relevant variable. In hypotheses where direction of misestimation was important, the first set was used; these being hypotheses (d) and (e).

From each sample, the number of subjects having significant positive or negative correlations was recorded. This was usually low (see table 4.12). Secondly, the directions of correlation were noted irrespective of significance. The number of subjects with positive correlations was compared to the number of subjects with negative correlations in each sample, and the significance of the result assessed in the usual manner. The implications of the two steps should be noted: the first stage shows the number of subjects of whom it is true to say that large amounts of their misestimations are actually explained by the hypothesis under test. The second stage merely indicates whether it is possible to say that, within the sample in question, there is a general tendency in the direction suggested by the hypothesis. The significance figures here will only indicate the tendency to be consistent, not to be strong.

The results of the first part of this analysis are expressed in

Table 4.12

NUMBER OF SUBJECTS
WITH SIGNIFICANT CORRELATIONS

Sample	ModRes v. CON		ModRes v. FAM		ModRes v. ATL		ModRes v. ATV		Res. v. FAM		Res. v. ATL		Res. v. ATV		N
	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve	
Aberdeen	1	5	2	5	7	2	1	2	1	4	2	2	4	2	46
Ayr		2	1	4	1	4	4	5		3	2	4	4	4	54
Berwick	1	5		3	5	1	6	6		2	4	3	3	7	64
Dundee	4	8	4	6	5	10	6	11	2	4	3	5	4	7	70
Edinburgh	2	4	4	1	6	6	6	9	2	4	6	5	3	7	56
Inverness	1	18	3	7	8	4	8	5	4	3	3	5	7	6	84
Lerwick	1	10		12	6	4	6	5		7	1	9	5	8	64
Newcastle	8	1	7	6	5	7	8	6	6	7	7	10	7	11	70
Stirling	1	4	3	7	7	4	5	7	2	5	6	6	5	7	67
Stornoway		1			1		1	2	1			1	1	1	21

KEY

ModRes = Modulus residuals
Res. = Residuals
CON = Confidence
FAM = Familiarity
ATL = Attractive to live
ATV = Attractive to visit
N = No. of subjects in sample

Significance is assessed at the 90% level.

Note that all cells are not necessarily mutually exclusive.

Table 4.13

SIGNIFICANCE OF CORRELATIONS

Sample	ModRes v. CON	ModRes v. FAM	ModRes v. ATL	ModRes v. ATV	Res. v. FAM	Res. v. ATL	Res. v. ATV
Aberdeen	--	--				--	
Ayr	--	--					
Berwick	--	--			--		-
Dundee	--	--					
Edinburgh							
Inverness	--	--		++	--	--	
Lerwick	--	--					
Newcastle							
Stirling	-	--				-	-
Stornoway		--			--		

KEY

- = no. of negative correlations significant at 90% level
-- = no. of negative correlations significant at 95% level or better
+ = no. of positive correlations significant at 90% level
++ = no. of positive correlations significant at 95% level or better

table 4.12; the second part in table 4.13 . Note that all five hypotheses are structured so as to be supported by negative correlations. Positive correlations contradict the hypotheses.

Table 4.12 shows that the total number of subjects in each sample whose misestimations are explained to a significant degree by any of the five hypotheses is low; therefore we must turn to table 4.13 for any more positive evaluation of the results. The tendencies shown in this table, as can be seen, support hypotheses (a) and (b) to a fair degree, and the rest little, if at all. It should be noted that hypotheses (a) and (b) are, in fact, closely related. Confidence in estimation is, not all that surprisingly, linked to a certain extent with familiarity. Certainly, when familiarity and confidence figures for each subject were correlated with one another, the results were found to be generally high, normally significant at the 90% level at least (values of r at around 0.6) and occasionally with r values in excess of 0.9, though some low, and even negative values of r did occur.

The conclusions of this test of valence would therefore seem to be as follows. There is a tendency in the data for distances to more familiar places to be more accurately estimated than those to less familiar ones, and the subjects seem by and large to recognise this fact in assessing their estimates. However, this is only a tendency, and it cannot be said that large amounts of misestimation can be accounted for in this way. There is little support for the hypothesis that unfamiliar places tend to be over- rather than underestimated in terms of distance. The data show that there is no support at all for the hypothesis that more attractive places are more accurately located, and insignificant support for the hypothesis that more attractive places tend to be underestimated in terms of distance.

It is perhaps worth noticing that the two samples which showed the least support for any of the hypotheses in this section were also the two largest urban centres. This could suggest that the extent to which familiarity influences accuracy may depend on the sort of urban centre from which the sample is drawn, but obviously, there is far too little data to assess such a contention.

A further test of the possible effects of attractiveness was made as follows: referring to table 4.8, the total plusses and minusses in each column were summed and expressed as a single differential. This differential was then taken as an index of the extent to which the distance to the place in question was underestimated. The eleven places were then ranked by differential, the lowest (most underestimated) first. The figures from table 4.6 were then also totalled by column, and the eleven places ranked by overall attractiveness, highest (most attractive) first. The rank orders were then compared (see table 4.14). Mere visual inspection suffices to show that apart from the fact that Newcastle and Dundee occur at the bottom of all three lists, there is evidently no consistent comparison. Values of Spearman's r were calculated, and though these are positive, they are low. For the comparison between distance estimation and attractiveness to live, the figure was 0.136; for attractiveness to visit, 0.200 .

In conclúsion we tend to agree with Canter (1975) that the valence hypothesis has little to be said for it.

(vi) Time and Distance

Since travel time and distance are both measures of separation and tend to be proportional to one another, the task of determining any relationship between estimated travel time and cognitive distance is a difficult one. To simply correlate estimated distance and

Table 4.14

ATTRACTIVENESS BY RANK ORDER

Place	Rank Order Underestimation	Rank Order ATL	Rank Order ATV
Aberdeen	8	2	2
Ayr	2	3	4
Berwick	9	5	5
Dundee	10	9	10
Edinburgh	6	1	1
Glasgow	3	10	9
Inverness	7	4	3
Lerwick	1	7	6
Newcastle	11	11	11
Stirling	5	6	8
Stornoway	4	8	7

estimated time might produce high figures, but this would not show that either was derived in any way from the other, merely that they are two different measures of the same thing.

It could be argued that time is the more fundamental of the two from the human point of view, both in primitive societies (vide the phenomenon of eskimo maps, which record direction and travel time only) and in modern ones (this was discussed in part II). It would therefore seem instructive to attempt to investigate the hypothesis that distance estimates are time-based.

Canter (1975) found a solution to the methodological problems surrounding the time/distance problem by basing his experiment on the London Underground where precise and absolute figures for actual travel time could be obtained. He found no support for the above hypothesis, that travel time was being used as a basis for distance estimates.

At this point it might be as well to distinguish here between estimation of distance and calculation of distance, although the latter is but a more accurate version of the former. There are two ways in which distance estimates can be based on time; the first is the subjective assessment of a journey, in which recollection of the length of time taken over travelling is instrumental in reducing or augmenting the subject's distance estimate. In the case of two journeys equal in mileage, the one which takes longer to traverse would be estimated as being the longer of the two distances. The second sort of case is confined to instances when the subject knows to a reasonable degree of accuracy the speed at which he travels, and is actually able to calculate the distance from a combination of time and velocity information. This latter is not relevant in Canter's experiment, since few passengers have information on the actual speed of Underground trains. In fact, calculations of this sort are not easily investigable in this sort of study, partly since they are not easily distinguished from other sorts of estimations, and partly since they tend to simply make up the more "objective" part of the results that is relatively free from misestimation. After all, the study of cognitive distance is generally directed to discovering why people get distances wrong, not why they get them right. The subjective influence of travel time is a cause (or at least, a possible cause) of misestimation, whereas the "objective" influence of travel time as the basis of accurate calculations is unlikely to be so (subject to such imponderables as calculations based on bizarre velocity figures). Consequently, following Canter, we will confine ourselves to attending to an investigation of the more subjective side to temporal influences on distance estimation.

However, the methodology devised for the present study was different from that employed by Canter. Rather than relying on absolute travel time, it took as its basis large-scale variations in absolute travel speed. The basic hypothesis is that if distance estimates are being influenced by travel time, those people who take less time to travel a distance should produce relatively lower estimates of distance. Therefore, those people who travel by faster means should be more prone to giving distance estimates that are in overall smaller than those given by slower travellers.

The first stage in the analysis was therefore to look for a relationship between the general size of time estimates and distance estimates. This was done by computing an average time estimate for each subject (from the ten estimates made by that subject) and an average distance estimate. These two components were then correlated for each sample. High correlations were looked for as indicative of a relationship between travel time and the magnitude of distance estimates, although this could still conceivably indicate that cognitive distances were influencing the size of time estimates, rather than vice versa.

However, high correlations were not forthcoming. Out of ten samples, only two had significant correlations at 90% or better. These were Berwick and Lerwick, which yielded r values of 0.34 and 0.33 respectively, both significant at the 99% level. Of the others, Stornoway gave a negative correlation of -0.16 .

However, this result is not really significant in itself. The lack of low correlations between the scales of the two different sets of estimations need not indicate that there is no relationship between the relevant cognitions (as opposed to estimations). Once again, the best way to tackle the problem is to use residuals as the truest measure of the misestimation (or misperception) of distance, rather than the mileage figures.

The following hypothesis was formulated: that if a subject would normally fly when making certain journeys (therefore taking relatively little time over travelling) and would normally travel overland when making certain other journeys (therefore taking relatively greater time), then he will be more prone to underestimating the former set of distances relative to the latter. In the case of most of the sample groups, very few of the distances in question were ones in which the possibility of air travel arose. However the Lerwick sample presented a special case, in that all the distances in question involved the possibility of air travel. (This may be a reason why the Lerwick sample was one of the two that gave positive results in the preceding correlation test.) Therefore this group was singled out for further experimentation. The Stornoway position is similar in its isolation, though less extreme, but the small size of the Stornoway sample restricted its use in this context.

In the experiment, for each subject in the Lerwick sample, the ten distances involved were divided into those which the subject had indicated he would fly, and those that he would have travelled by sea and land. Then the regression residuals previously obtained from the parallel regression experiment were processed, so that the average residual for "air distances" and the average residual for "sea/land distances" were calculated and compared to one another. The hypothesis as tested would predict that the residuals associated with air distances would tend to be lower than the residuals associated with sea distances, showing that the subject had a tendency to underestimate the former.

Of the 66 Lerwick subjects, only 49 yielded results that allowed such a comparison to be made (after exclusion of those subjects who were totally consistent in their travel habits). Of these, 40 turned out to have lower average residuals with respect to distances travelled by air, and only 9 showed a contrary tendency. This result is highly significant (at greater than 99.99%). The hypothesis is therefore confirmed, since it seems that the faster speed of air travel, in reducing travel time, is an influence on the perception of distance, and is associated with a tendency towards underestimation.

There is an apparent objection to this result, namely that distances flown should naturally be estimated as relatively shorter compared to distances travelled over sea and land, since air routes are shorter than overland routes. However, this disparity between direct and crooked routes has already been compensated for by the parallel regression technique, so the objection is not really valid. This can be shown by examining the mileage estimates, which one would expect to follow a similar trend were it the shorter air distances that were causing the result. Indeed, it is in the mileage figures that one would expect the effect to be most marked, since the

Table 4.15

AIR/SEA TRAVEL FROM LERWICK

(Comparisons of mean distance as estimated by air and sea travellers, together with standard errors)

Lerwick to:	AIR Distance	S.E.	SEA Distance	S.E.
Aberdeen	190	09	190	09
Ayr	325	35	332	13
Berwick	391	41	363	13
Dundee	277	41	255	07
Edinburgh	313	13	306	10
Glasgow	323	13	324	11
Inverness	193	13	186	16
Newcastle	394	22	456	20
Stirling	302	29	286	08
Stornoway	263	17	306	28

(All figures given to nearest whole number.)

residuals have had the disparity between direct and road distances strained out, whereas the raw mileage estimates have not. For each distance, the average mileage estimate given by the air travellers was calculated and compared to the average estimate given by the sea travellers; the results of this are presented as table 4.15 . As can be seen, the figures associated with air travellers are not significantly lower; if anything, they tend to be slightly higher. This strongly suggests that the shorter distances of direct air routes are not the cause of the underestimation of distances travelled by air (as was previously described in this experiment).

The experiment was repeated using the Stornoway group, but appropriate comparisons could only be made amongst 13 subjects. The results were that 9 gave results confirming the hypothesis (lower air residuals) and 4 gave converse results. With only this small number of subjects the experiment cannot be regarded as significant.

While the above experiment is both small and simple, the results are noteworthy in two respects. Firstly, this is the first experimental evidence in favour of the hypothesis that experienced time is contributary to perceived distance. Secondly, the fact that the results did show a significant tendency in the predicted direction is encouraging in the consideration of the general hypothesis that spatial variables, especially those that may be considered as dimensional parameters of physical space, are influential in guiding the translation of objective space into cognised space.

(vii) Barriers

Once again we come to the problem of barriers. Can it be shown that conceptual "events", located in space, and loosely summed-up by this word "barriers" have an effect on whether a distance is overestimated or underestimated?

The Anglo-Scottish border has already been discussed earlier in the text; it has also been suggested that barriers may be non-commutative. To further investigate this, four different "barriers" were hypothesised in the study area. These were: the previously-mentioned border, the north-south watershed dividing the east coast from the west, the Grampian mountains, and those arms of the sea (the Minch, Pentland Firth, etc) that separate the islands involved in the survey from the mainland.

Each of these was investigated in turn. The distances that traversed each barrier were assessed as overestimations or underestimations with reference to the left-hand components of table 4.8 . The results were then totalled, once for distances crossing the barrier in one direction, then for the other direction. The results are given in table 4.16 .

With the number of figures available, it is difficult to calculate a statistical significance, but visual inspection is sufficient to reveal some interesting results. One is that in all four cases the results are very different depending on the direction in which the barrier is traversed. The Scottish border has no effect in a northward direction, but is associated with heavy overestimation going south. With regard to the watershed that divides the two coasts, the proportion of overestimation to underestimation is virtually reversed as one changes direction, though with half the distances in either direction falling into the "not significant" category. The Grampians exert an effect similar to the border: going north there is no discernable effect; going south, overestimation is predominant. The sea has another partial reversal effect - though many distances are not significantly misestimated, those that are, are all underestimated northwards, and mostly overestimated

Table 4.16

BARRIER RESULTS

Barrier	Direction	Overests.	Underests.	Not Significant
Anglo-Scottish	going N	5	7	6
Border	going S	13		3
Scottish	going E	7		7
Watershed	going W	2	9	10
Grampian	going N	3	2	7
Mountains	going S	10		4
Minch &	going N		7	9
Pentland Firth	going S	8	3	7

Numbers indicate number of distances crossing each barrier that were significantly overestimated, significantly underestimated, or neither.

southwards. It is interesting to note that the marine barrier does seem to exert a positive barrier in one direction, despite the conclusions reached in part III regarding the effects of sea.

The fact that all four hypothesised barriers have markedly asymmetrical effects would seem to be highly significant. The first thing it suggests is that mere physical occurences do not of themselves constitute perceptual barriers. They have to be interpreted as such, (after all, a divide such as the Anglo-Scottish border is not much of a physical occurence anyway) and they may be interpreted differently depending on which side of the fence the subject is. The second point arising is this: if one categorises each side of the four barriers as either more or less "central" in demographic/economic terms then one finds the interesting property that overestimation is always in the direction of greater centrality, e.g. across the mountains towards the lowlands, etc. The suggestion is that marginal areas are more acutely aware of the things that separate them from more central areas, while subjects in central areas are much less concerned about or ignorant of the barriers that lie between themselves and the periphery. Furthermore, though this effect of overestimation towards the centre seems to work in the cases of significant barriers (at least, the four tested), where distances cross no such barrier the effect is not so marked. For instance, it is Edinburgh that overestimates the distance to more peripheral Dundee and Aberdeen, and not vice versa. This is an interesting point which possibly warrants further attention.

(viii) Conclusion

We can conclude this part with a retrospective look at the original aims of the experiment. In doing so it may also be possible to sort out some of the divergent results obtained from different techniques.

The question of commutativity was one of the topics on which contradictory results were obtained. When using mean mileage figures (aggregated over the whole sample), a fairly stringent test of non-commutativty yielded positive results in a minority of circumstances. These were usually distances which were both long and difficult to estimate. However, when the terms were re-defined so that commutativity was measured in terms of relative cognition rather than absolute estimates, the pattern changed, and it appeared that only a minority of links were viewed in the same manner from either end. Not only is the first method of analysis theoretically weaker (it does not benefit from the standardising effects of regression analysis), but the latter approach seems much more relevant to the topic as a whole, and the conclusions to be drawn are that the distances as surveyed were not perceived in a commutative fashion in the majority of cases. In the minority that were, it is impossible to discern any common determinant factor that could be used to predict commutativity.

The use of confidence estimation in an attempt to explain inaccuracy of estimation by the subject's own admitted ignorance was more succesful at this scale than at the global level. However, the tendency for low confidence figures to accompany high residuals was a tendency only, and the total amount of explanation of misestimation was not high. Degree of confidence was closely related to familiarity.

As with the global distances, a non-linear logarithmic model turned out to explain distance estimates better than a simple linear one. It is strongly suspected by the author that this is a result of estimation rather than cognition.

Consistent overestimation of all distances by a subject group, would, in relative terms, be overestimation of none of them. However, consistent overestimation of the distance to a particular place by all the subjects in a group, or, for that matter, all the other subject groups, is quite possible. Within each subject group distances that were consistently misestimated were readily identifiable; the degree to which other subject groups also misestimated the distance to the same place varied considerably. With regard to the problem of the same distance being viewed by two different subject groups (at either end - this is the commutativity test again), as has been mentioned, the majority of cases showed differences in misestimation.

Four potential cognitive barriers were examined, and all yielded interesting results. Of the four, one was an obvious physical land barrier (the Grampians and Scottish Highlands), one a physical barrier of the marine variety, one a barrier partly physical and partly cultural (the watershed) and the last was a political/cultural/national boundary. All four were similar in that they had different effects depending on the direction from which they were viewed. This is a significant point, and is possibly the result with the highest potential for further research study. In particular, it would be interesting to know a lot more about exactly how people perceive and react to barriers of different sorts.

The relationship between estimated distance and time was examined. Within the limitations of the experiment, the results were suggestive of an influence exerted by experienced time upon perceived distance.

The influence of familiarity and attractiveness on cognitive distance was examined, and it was found that though there was a significant tendency in the data for more familiar places to be more accurately estimated in terms of distance, attractiveness played no role at all.

By and large, the results of this experiment tend to confirm those of the previous one on global distances where the two can be compared. It expands on the findings in significant areas by the inclusion of extra tests on such matters as commutativity, time-distance, familiarity and attractiveness, and also in the further important findings on the apparent nature of cognitive barriers.

PART V

CONCLUSION

In summing up, we must return to the original aims of the thesis to see to what extent they have been fulfilled.

It was of prime concern to establish that a purely geographical methodology was a viable approach to the problem of cognitive distance. In order to do this, it was necessary to find significant patterns of misestimation that were related to place rather than to inter-personal variations. The fact that at both scales of investigation in the preceding work it was possible, in the majority of cases, to speak of a particular distance being significantly overestimated or underestimated by the sample as a whole seems to indicate conclusively that geographical variables do indeed have an important effect on the cognition of distance. A geographical approach to the subject is therefore definitely relevant. This does not mean that a psychological or sociological approach is not valid, but any further research on psychological or sociological lines will have to take into account the fact that geographical variables have a sizable effect which may have to be compensated for if purely psychological variables are to be investigated.

The next point to consider is the extent to which some sort of comprehensive geographical theory can be constructed from, or is suggested by, the preceding material.

Firstly, we must concern ourselves with the general relationship between cognitive distance and physical distance at the two scales examined. In all the experiments conducted the results showed that this could best be expressed by the formula

$$\log y = a + b.\log x$$

where x is physical distance, y is cognitive distance, a is a constant (usually small), and b lies, on average, within the range 0.85 to 0.95 . The experiments at the greater scale tended to give , on average, lower b values means, and more divergence about the mean;

the Scottish experiment gave higher and more consistent b values. (This may, of course, reflect in part the different techniques employed in the two experiments.) What was most striking was the similarity of results between each sample group in both experiments. As for the values of the constant a, these, on brief inspection, tended to be small and uninteresting.

The implication of these results is that the perception of geographical distance would seem to reflect a curved cognitive space, rather than a Euclidean one. This has its counterparts in existing geographical canon, for instance in the use of logarithmic map projections to show population migration (Hägerstrand, 1957). However, it cannot be positively determined as yet whether this effect is really a product of the nature of cognitive space, or whether the curvilinear trend has crept in from the estimation processes instead. At least, from a pragmatic point of view, we can say that whether or not minds actually cognise space as being curved, they appear to behave as though they do, which is useful in itself. As previously discussed, an interesting experiment would be to give a sample of subjects a distance estimation task similar to the preceding ones, but to have them complete the questionnaires while looking at a large wall map showing the location of all the places involved. Instructing the subjects to use this map as their frame of reference would eliminate the cognitive element entirely. If the results were still in a logarithmic form this would indicate that the logarithmicity is a product of the mechanisms of estimation rather than cognition. Unless, of course, one takes the psychophysical perspective of maintaining that the results would indicate distortions in visual perception. However, whatever the origin of this curvilinearity, it would seem to be a basic necessity of any predictive model of distance estimation.

Given this regression equation as the underlying basis of cognitive distance patterns, how do we explain the various divergences from this? The hypothesis that apparently significant misestimations could be explained by sheer ignorance of an admitted kind on the part of the subject was tested in both experiments and was proved unsatisfactory in both cases. There was a tendency in the Scottish experiment results (but only a tendency) for misestimation to increase with unfamiliarity, but this did not explain the direction or amount of misestimation.

Using place characteristics as explanatory variables produced little in the way of positive results. In the Scottish experiment estimated attractiveness was used as a variable, but no significant relations between this and estimated distance could be discerned. Using such variables as urban size was considered, but even visual inspection of the results was sufficiently revealing to dissuade the author from proceeding further in such a direction. It will be noted that place characteristics, perceived or otherwise, are point variables rather than spatial variables; they therefore do not relate directly to the distances in question. In this respect their failure to account for variations in cognitive distance may well be significant. The suggestion is that estimates of distance, as spatial measures, are more influenced by other spatial factors than by non-spatial variables. These various spatial factors were discussed in part II, and included the viewing of time and matter as spatial parameters, as well as a consideration of the geometry of space. We can turn first to geometry.

Most of the material relating to metric geometry and cognitive space was gathered in the Scottish experiment rather than the global experiment. Even so, there were certain aspects of the question that could not effectively be tested given the experimental conditions.

The metric property of non-degeneracy, for instance, cannot be taken for granted. It is possible for two distant points to be cognised as having effectively no distance between them under circumstances where the subject is aware of their distance from his location, but has no cognition of their positions relative to one another. However, it is unlikely that any subject is actually going to estimate the distance between, say, Samarkand and Tashkent as zero miles, since this goes contrary to common sense. Nevertheless, if the subject is unable to distinguish between the two locations, the Samarkand-Tashkent distance becomes effectively degenerate. This condition is approached in the results of one urban study previously mentioned (Brown, 1974).

Non-negativity is rather easier to establish since the idea of negative distance has no significance in cognitive studies to date. The triangle inequality, though, suffers again from the problem that it cannot be accurately tested without asking subjects to estimate remote interdistances, and the author has been reluctant to do this for reasons previously discussed. A useful topic for further research would be the study of the relative accuracy of remote interdistance estimations compared with estimates of distance from the subject, and this could be combined with a specific test of the triangle inequality. Also of interest in this context would be a detailed study of the differences in estimations made by subjects resident in their native city to those made by subjects resident in non-native cities. Some approach could be made to the the question of the examination of the triangle inequality by a re-examination of table 4.1; it will be seen that in these figures it generally holds (not unsurprisingly, in most instances), but with exceptions. The Aberdonians' mean estimate of the distance to Berwick exceeds the sum of their mean estimate of the distance to Dundee and the Dundee residents' mean estimate of the distance to Berwick. In the reverse direction the triangle inequality does hold - but by a margin of only one mile. But these calculations mix subject groups in such a way as to produce results that tend somewhat towards the hybrid. Furthermore, Aberdeen, Berwick and Dundee only form a triangle in Euclidean space. In the network space of Scottish roads, Dundee is directly on the line between the other two. With but a shift in perspective, a triangle becomes a straight line, illustrating the complexity of the problem.

The analysis of symmetry is altogether more reliable. This is another topic that has beeen difficult to test, since to ask subjects to estimate the distance from Edinburgh to London and then to ask them the distance from London to Edinburgh is not likely to enhance the experimenter's reputation for common sense. Even if some time is allowed to elapse between questionings, results are not likely to be very different. Stea (1969a) attempted to solve the problem by splitting his sample randomly and asking one half the distance "to" each place, and the other half the distance "from" each place; this, though, still suffers from the problem of estimation of distance from a remote place; it is also impossible to tell whether or not a subject might, when asked the distance from a remote place to his location, invert the question before answering it. But in the Scottish experiment, it was possible to use a comparison between different subject groups at different ends of a particular distance, owing to the technique used to assess distances as significantly under- or overestimated by a particular group. By using "misestimation status" rather than mean distance estimates, valid comparisons could be made, and these showed a tendency against symmetry. That is to say, if a distance AB was significantly underestimated by the residents of A, on average it would not be significantly underestimated by the residents of B. In relative terms at least, therefore, cognitive space, as measured by the experiment, would seem to be asymmetrical.

Turning now to the matter of what was referred to as "dimensional substitution" in part II, it will be recalled that this was seen as the perception of space being influenced by variables which were themselves inherently spatial in nature. The potentially important "spatial" variables were considered to be time and matter; in this context time takes the form of travel time, and the influence of matter is a function of "perceived matter", "perceptual events" or "perceptual barriers".

Considering the widespread nature of "conventional" time/space substitution, it was hypothesised that travel time might be an influential factor in distorting distance cognitions. The experiment conducted in Part IV, though localised, did produce significant results in the direction predicted by the hypothesis. There is scope for further experimentation of a "controlled" kind, in which different groups of subjects would be asked to traverse the same distances at different speeds and then asked to estimate the distances in question. Such an experiment would be far more likely to produce significant results than one in which subjects are merely asked to estimate travel times.

While it would be an exaggeration to say that the results of the Lerwick experiment suggested that distance was perceived purely in temporal terms, the results do indicate a temporal influence on distance perception. This is consonant with the hypothesis of "dimensional substitution", which process should not be regarded as necessarily absolute and exclusive.

Looking at barriers and events, although the results in this direction have been promising, there has been a certain difficulty in qualifying and quantifying exactly what constitutes a "perceptual event". The system used in the global experiment produced surprisingly good results considering the crudity of the measures used. In the Scottish experiment, rather than the application of a similar correlation technique, a comparitive approach was adopted to see if hypothetical barriers had the same effect when viewed from either direction. The results of this showed that perceptual barriers were strongest when viewed from the less "central" side, at least at the scale and in the context of the experiment. Certainly, the effects observed were markedly asymmetrical. This implies that geographical features have different effects on distance estimation that depend on the view taken of the particular feature. This, in its turn, may depend on the location of the subject.

This is very important, and is perhaps one of the results of this work that most merits further investigation. There is a potential for controlled "laboratory" type experiments in which certain distances are either chosen or constructed in order to consist of a discrete number of events of a particular kind. The reaction of subjects to these distances (in terms of estimations) can then be compared to the pre-determined number of events, and also the subjects' reaction to the type of event can be investigated at the same time. By attempting to hold various features constant, and test one variable at a time, it may be possible to ascertain more definitely what sort of perceived barriers and events most contribute to cognitive distance, and to what extent. At the same time we must note that the objective "contents" of a particular amount of space are not the same as the subjective or cognised contents. The extent to which these cognised contents vary from objective reality may vary geographically, in terms of location of subject group (as was suggested by the experiment) but it may also vary sociologically (which was not investigated at all). One recalls the cognitive mapping experiments of Orleans in which subjects of higher social class were found to have more detailed cognitive maps (Orleans, 1967). An experiment involving cognitive mapping carried out by Canter suggested that those who made more detailed maps also made more overestimations of distance (Canter, 1975). However, social factors seem incapable of accounting for the striking differences in over- and underestimation found in the Scottish experiment. Considering the noted apparent effects of "centrality" it would appear that social variations can only be part of the story; a hypothesis that accords greater awareness of barriers to those on the remoter side of them looks to be at least plausible.

Overall, then, the single most important conclusion of this study is probably the fact that it definitely seems that the relationship between cognitive and physical distance is best accounted for in terms of the geometry and nature of cognitive space, rather than in terms of non-spatial variables. This includes the hypothetically spatial parameters of time and matter, both of which showed influences in the predicted direction. This result confirms that cognitive space is a viable and useful concept, and it is therefore potentially fruitful to make comparisons between cognitive space and philosophical theories of physical space.

These comparisons can, if desired, be two-way. From the theories discussed in part II we drew much inspiration for the direction of experiments in parts III and IV. It is equally possible to argue that, since true objectivity is never possible, the characteristics of space as perceived make a useful yardstick by which to evaluate theories of the characteristics of physical space itself. This may seem a vulgarly democratic way to approach philosophy (and it would have been deplored by Newton), but at the very least it gives a new slant to "the esse is the percipi".

The resulting perspective is one of a space that owes little to absolutism or to Euclid, but rather leans towards Berkeley and Descartes. It is a space that appears to have a geometry both curved and irregular. It is a space towards which patterns of matter seem to contribute significantly, as do variations in experienced travel time.

Physical space has usually been considered by philosophers to be a very pure stuff, and our cognitve space is loose, variable, and anything but pure. To many it may seem that to adopt a perspective on the former based on analysis of the latter is a terrible hypostasisation. But the relationship between the two does exist. Cognitive space cannot escape considerations of physical space. The extent to which one accepts the possibility of a relationship in the other direction depends on one's individual attitude towards matters of objectivity and subjectivity.

The work is not yet over; much more testing will be necessary before it becomes possible to say that a theory of cognitive distance has been completed. I hope that this study has pointed out some of the directions further research should take, and that it has contributed to solving the methodological problems of such further research. There is more to be done yet before we fully understand the perception of geographical distance and the philosophy of space.

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DISTANCE ESTIMATION QUESTIONNAIRE (See next sheet also)

The following places are arranged in a random order. (Column 1)

(i) Re-arrange them in order of increasing distance from Edinburgh. Use Column 2 for this.

(ii) Taking the shortest distance from Edinburgh to London as one unit, estimate the shortest distance from Edinburgh to each place on the list in terms of Edinburgh/London units. Give your answers as a single figure in each case. (e.g. $\frac{1}{2}$ = distance is half as far as Edinburgh to London; 12 = distance is twelve times as far.) Use column 3 for your estimates.

(iii) Evaluate how accurate you think each of your answers is. Give your answer as a single figure from one to ten, on the scale 1 = pure guess, no idea how far it is ... 10 = certain that this is very accurate. Use column 4 for these answers.

(iv) If you think you know the actual mileage to any of the places, write the number of miles in column 5. If you do not know the mileage, leave a blank. DO NOT ATTEMPT TO ESTIMATE MILEAGES IN COLUMN 5.

(v) If you think you know the mileage to London, write the figure in this space: ________________ DO NOT ESTIMATE THIS DISTANCE.

(vi) Tick any cities appearing in column 1 that you have visited.

Column 1 RANDOM LIST	Column 2 RANKED LIST	Column 3 DISTANCE	Column 4 CONFIDENCE	Column 5 MILEAGE

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SCOTTISH TOWNS QUESTIONNAIRE

Please answer the following questions on your own; it is important that you do not consult any sources or anyone else. You do not need to take long over any of the questions. Where applicable, please record your answers in the boxes provided.

(1) How far away from here (in miles) would you say the following places were?

Ayr	80
Aberdeen	120
Berwick on Tweed	110
Dundee	60
Edinburgh	35
Glasgow	25
Inverness	140
Lerwick (Shetland)	300
Newcastle on Tyne	150
Stornoway (Lewis)	200

(2) How accurate do you think your answers to Question 1 are?
Give each town a number on the following scale:
5 = very accurate 4 = fairly accurate 3 = moderate
2 = poor 1 = just a guess

Ayr	3
Aberdeen	3
Berwick on Tweed	3
Dundee	4
Edinburgh	5
Glasgow	5
Inverness	4
Lerwick (Shetland)	1
Newcastle on Tyne	2
Stornoway (Lewis)	1

PTO

(3) If you had to travel to each place in the near future, how would you travel? Give your answer as a number on the following scale:
1 = car   2 = rail   3 = bus   4 = car/boat
5 = rail/boat   6 = bus/boat   7 = air.

Ayr	1
Aberdeen	1
Berwick on Tweed	1
Dundee	1
Edinburgh	1
Glasgow	1
Inverness	1
Lerwick (Shetland)	7
Newcastle on Tyne	1
Stornoway (Lewis)	7

(4) How long (in hours) do you think it would take you to travel to each place?

Ayr	2½..
Aberdeen	..4...
Berwick on Tweed	.2...
Dundee	.2...
Edinburgh	..1....
Glasgow	..1....
Inverness	..4...
Lerwick (Shetland)	..2..
Newcastle on Tyne	..5...
Stornoway (Lewis)	..2..

(5) How attractive do you think these towns are, (a) to live in (assuming employment, education etc., to be no problem) and (b) to visit?
Use the following scale for your answers:
5 = very attractive   4 = fairly attractive
3 = no opinion   2 = fairly unattractive   1 = very unattractive.

	(a) To live in	(b) To visit
Ayr	5	5
Aberdeen	2	2
Berwick on Tweed	4	4
Dundee	1	1
Edinburgh	3	5
Glasgow	1	2
Inverness	1	5
Lerwick (Shetland)	1	3
Newcastle on Tyne	1	2
Stornoway (Lewis)	1	3

(6) How well do you know each town? Use the following scale for your answers:

5 = have lived there 4 = have been there frequently

3 = have been there fairly often

2 = have been there occasionally 1 = have never been there

Ayr	4
Aberdeen	3
Berwick on Tweed	3
Dundee	3
Edinburgh	4
Glasgow	4
Inverness	3
Lerwick (Shetland)	1
Newcastle on Tyne	3
Stornoway (Lewis)	1

(7) What is your occupation? Computer Programmer

(8) What is your sex? M ☐ F ☑

(9) Where were you born? Bridge of Allan

(10) How long have you lived in Stirling? 5 years